THE ECLECTIC PHYSIOLOGY.

Plate I.

BONES.

THE STROBRIDGE LITH. CO. CINCINNATI, O.

THE ECLECTIC PHYSIOLOGY

FOR USE IN SCHOOLS

BY

ELI F. BROWN, M. D.

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PREFACE.

THE following treatise upon the human body has been prepared with special reference to its use in schools. Only such matter is given as seems needful to enable the pupils to fairly master the subject. Much useful supplementary material is added in the notes.

The succession of topics adopted is such as long experience has determined is the best. The simplest parts are studied first; the most complex portions are considered last. The succession of topics is based on a plain order of dependence. Each subject is presented methodically. Simple topical outlines are annexed to the chapters to guide the pupils and teacher in systematic study and recitation.

In presenting the various vital processes, and in the examination of any great organ, attention is first given to the structure and use of parts. Hygiene then follows closely, because the discussions of structure and use determine the hygiene, and point to its immediate consideration.

This subject is taught in the common schools in order to impart a clear knowledge of the nature and use of the body, and to impress forcibly the ways and means of maintaining

its health and vigor. For these reasons, the subject matter is here presented in a plain, didactic style; common words are usually employed, instead of technical terms, and the details of anatomy are subordinated to the more important consideration of physiology and hygiene.

Much attention is given to the care of proper sanitary conditions in the home, and to habits of healthfulness in ordinary life. Emphasis is given to the discussion of such habits as lead to pain and disease. The effects of narcotics and stimulants on the body and mind are set forth plainly and fully. The character of alcoholic beverages, tobacco, opium, etc., receives special attention.

To teach physiology well, the teacher needs to prepare ingenious experimental illustrations, and to present to his class the examinations of appropriate materials from slaughtered animals. The teacher ought to know much more than these lessons contain. What is here given is designed for the pupils to learn. The teacher is advised to study carefully the works of such authors as Gray, Flint, Huxley, Draper, Carpenter, and others of like character. In the preparation of this treatise, free use has been made of all the materials that constitute the great body of the science.

ELI F. BROWN.

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PHYSIOLOGY.

CHAPTER I.

INTRODUCTORY.

Article 1. Kinds of bodies.—The separate things we know about us are called bodies. By noticing these bodies we may see that there are two kinds: (1) bodies that do not live, (2) bodies that do live. The stones, the soil, the water, the air, pieces of iron, and such things, do not live and do not grow; while the trees, the grass, the corn, the birds, the flies, the people, and such things, do live and grow.

2. Contrast of non-living and living things.—Non-living bodies are formed and become larger by the addition of substance to the outside. Living things grow by taking food into themselves, which food they change so that, finally, it becomes a part of them.[1] *

Non-living bodies are not inclined to change, but usually endure for a long time in the same condition. Living bodies originate from parent bodies, they live and grow for

* These numerals throughout the book refer to the corresponding notes at the end of the chapter.

a short time, and then die. No living thing can exist long as an individual. If we examine a non-living body we shall find that all of its parts are much alike. For instance, the pieces of a stone are of the same kind, and are like the whole stone. The parts of a living thing are often very different. The roots of plants are not like the leaves. The bones of animals are not like the flesh.

3. **Organs.**—The parts of a living thing are for different uses in the life and growth of the body. The roots of the plant absorb food from the soil. The leaves take food from the air, and change the food till it is prepared to become a part of the plant. The bones of animals support the body, the lean flesh moves the body, the eyes aid in seeing, the ears give hearing, and many other parts perform other uses.

The different parts of a living body which perform the many kinds of work in the body are called *organs*. Thus the mouth is the organ for chewing, the heart is the organ for sending the blood through the body, the eye is the organ of sight, the lungs are the organs for breathing.

4. **Plants and Animals.** — Living things are of two kinds: (1) plants, and (2) animals. Plants take their food from the air and water; they have roots for the soil and leaves for the air and sunshine. Animals must have food that has been prepared for them by plants. Thus the horses and sheep feed on grass, the bees on the sweets of flowers, and men eat grains and fruits.

A plant can not feel and is fixed to the soil by roots. Animals feel, they move freely, and show by their actions that they are intelligent. The lowest kinds of animals have very little feeling, and show scarcely any intelligence; they are much like plants. The higher animals are quick to move, acute in feeling, strong in action, and possess much intelligence. Man is the most highly developed animal.[2]

5. **Human Body.**—The human body is the only erect animal body. The average adult male Caucasian is five

feet eight and one half inches in height. The weight is one hundred and fifty pounds. The circumference of the chest is thirty-six inches.

6. **Systems of Organs.**—The body is extremely complex in the systems of organs that operate in it.[3]

The chief systems of organs are as follows: (1) The bones, (2) the muscles, (3) the digestive apparatus, (4) the circulatory system, (5) the respiratory organs, and (6) the nervous system.

The bones support, the muscles move, the digestive apparatus changes the food, the circulatory system distributes the blood, the respiratory organs perform breathing, and the nervous system enables us to feel and to control the whole body.

7. **Parts.**—The parts of the body are quite simple. They are as follows: (1) the head and neck, (2) the trunk, (3) extremities. The head consists of two parts,—the face and skull. The trunk consists of two parts,—the upper portion, called the chest, and the lower part, called the abdomen. The extremities are known as the upper and lower.

8. **Self-study.**—In the study of the human body, we should bear in mind that we are learning about our own body. We need to examine it, and to find in it illustrations of what we learn. We can feel our own bones, muscles, joints, and skin. We can feel our own heart beat. We can observe our own breathing. Our own nerves tell us what feeling is. We know what hunger is. We know what health and sickness are.

9. **Why study Physiology?**—We study the human body so that we may learn how to take care of it. Good health is one of the choicest blessings. It is hoped that the pupil will learn such lessons about the uses and care of his body that he may avoid disease, and make of his body a fit abiding place for the soul.

Notes.

1. **Structure of Stones.**—The stones do not grow. They are formed. We may think of a tiny grain of stone, and, as matter of the same kind adheres to it on the outside, the grain becomes larger. Or the reverse may be true. A very large stone may wear away by the action of air, water, or other substance, and finally, by losing bits of itself, it becomes a tiny pebble or grains of sand. We can not tell how old the stones are. Many of the quartz pebbles that we step upon may have been formed in the early stages of the earth's development.

2. **Plants and Animals.**—Many plants move upon being touched. Many of them move as freely as do some of the lowest animals. Some plants feed, in part, at least, on animal food. The "Venus Flytrap," and the "Sun Dew," are the most remarkable of the sensitive plants. Many of the lowest animals are like plants. They are fixed to a base, and do not move from place to place. Their parts resemble leaves and flowers. They have but little feeling, and show no intelligence.

3. **Cells.**—Microscopic examination shows that every portion of the body is made up of minute sack-like forms, called cells. These cells are held together by various kinds of substance placed between the cells. The cells are the living, growing parts of the body.

The cells are composed of an outer membrane and the contents of the membrane. The contents are usually fluid. The body grows by the increase in the number and size of the cells.

The cells are formed into tissues. Thus, we have bony tissue, in which there is lime deposited among the cells, and cartilaginous tissue, in which there is elastic matter between the cells.

The various tissues are as follows:

1. Bony tissue, which is hard.
2. Muscular tissue, which has the property of contraction.
3. Connective tissue, which is tough.
4. Cartilaginous tissue, which is elastic.
5. Adipose tissue, which is fatty.
6. Nervous tissue, which is sensitive.

Suggestive Questions.

What is a body? What are non-living bodies? What are living bodies? What are organs? What are some of the organs of a

plant? What are some of the organs of an animal? How do plants differ from animals? What are the dimensions of the average white man? What systems of organs are there in the human body? What are bones for? What are muscles for? What are the parts of the body? What use may the pupil make of his own body in the study of physiology? Why should we study physiology? Of what value is good health?

Topical Outline.

- Bodies.
  - Definition.
  - Kinds.
    - Non-living.
      - Formed by addition to outside.
      - Not disposed to change.
      - All parts alike.
      - Have no organs.
    - Living.
      - Grow by taking food inside.
      - Originate from parent bodies.
      - Have a season of life.
      - Die.
      - The parts are unlike.
      - Have organs.
  - Kinds of Living Bodies.
    - Plants.
      - Food, from air and water.
      - Have roots and leaves.
      - Fixed by roots.
      - No feeling.
      - No intelligence.
    - Animals.
      - Food taken from plants.
      - Have no roots or leaves.
      - Move.
      - Feel.
      - Intelligent.
- The Human Body.
  - Position.
  - Height.
  - Weight.
  - Circumference.
- Systems of Organs.
  - Bones.
  - Muscles.
  - Digestive.
  - Circulatory.
  - Respiratory.
  - Nervous.
- Parts.
  - Head.
    - Skull.
    - Face.
  - Trunk.
    - Chest.
    - Abdomen.
  - Extremities.
    - Upper.
      - Right.
      - Left.
    - Lower.
      - Right.
      - Left.
- Self study.
- Purposes of the study of Physiology.

CHAPTER II.

THE OSSEOUS SYSTEM.

10. By pressing on the arm, we find the outer parts are soft and the deeper portions are hard. These hard portions are the bones. They form the frame-work known as the skeleton.[1]

11. Uses of the Skeleton.—The skeleton gives: (1) general shape and permanency of form to the body; (2) by the aid of the fleshy portions that are attached to the bones, the skeleton supports the body in any desired position; (3) the skeleton, by the aid of these soft parts, enables us to move and extend the limbs, as in walking and in reaching out the arms; (4) the skeleton protects many of the more delicate organs by furnishing bony cavities for their safe lodgment. For instance, the unyielding skull shields the brain, the cage formed by the ribs incloses the lungs and heart, and deep sockets protect the eyes.

12. The number of bones that unite to form the skeleton is somewhat variable: anatomists usually recognize 206, besides the teeth.[2] The bones are divided into four great groups: (1) the bones of the head; (2) the bones of the trunk; (3) the bones of the upper extremities; (4) the bones of the lower extremities.

13. **The bones of the head** are divided into the bones of the skull and the bones of the face. The bones of the skull are eight in number. They are broad and curved, so that when joined at their edges they form the walls of an oval cavity. This cavity contains the brain. Their edges interlock in strong, irregular seams, called sutures, which hold the bones firmly together. A thin packing of cartilage is placed in the sutures. This cartilage has two uses: (1) it permits very slight motion in the suture; (2) it renders the shock from blows less severe to the brain, and the skull less liable to fracture.[3]

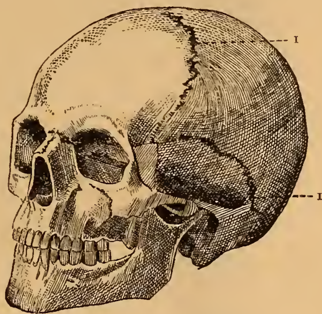


Fig. 1.
THE SKULL.—1. Sutures.

There are fourteen bones of the face. They are firmly fastened upon the front and lower portions of the skull. They are rigidly united with one another, excepting the lower jaw, which is free to move in opening and closing the mouth. These bones are extremely irregular in shape. They form the sockets of the eyes, the bridge of the nose, the prominence of the cheeks, the roof of the mouth, and the jaws.

There is a U-shaped bone at the base of the tongue, called the hyoid bone, that aids in moving the throat in swallowing and in speaking.

14. **The bones of the trunk** are divided into: (1) the bones of the spinal column; (2) the bones of the chest; (3) the bones of the pelvis. The spinal column, or "back bone," extends from the head along the back, and supports the upper part of the body on the pelvis. This column is formed of twenty-four pieces, called vertebræ. These vertebræ are placed one upon another, with layers of car-

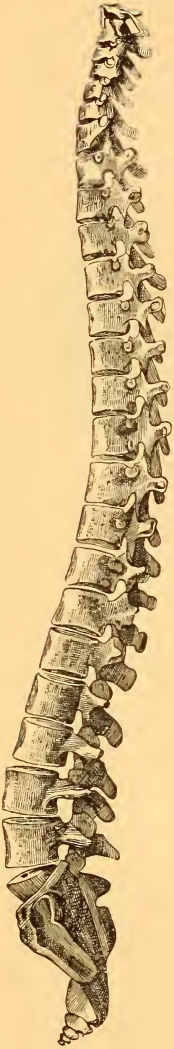


Fig. 2.
THE SPINAL COLUMN.

tilage between. This cartilage allows each vertebra to move a little.[4] The combined motion of the vertebræ enables the spinal column to bend readily in any direction. The column is exceedingly strong. An opening extends lengthwise through the center of this column, for holding the spinal cord.

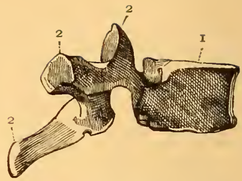


Fig. 3.

VERTEBRA, Side View.—1. Body. 2. Processes.

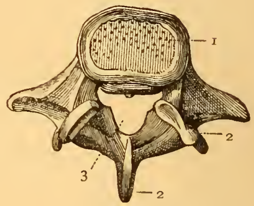


Fig. 4.

VERTEBRA, Top View.—1. Body. 2. Processes. 3. Opening for Spinal Cord.

Each vertebra is broad in front. This broad part sustains the pressure of the column. On the sides and back portion, there are many irregular processes, by which the vertebra attaches to the various parts that surround it.[5]

15. **The bones of the chest** form a conical, bony cage. The bones that form the chest are a portion of the spinal column behind, the sternum or "breast bone" in front, and the ribs at the side. The sternum is a flat bone, to which the cartilages of the ribs join in front. In a young person, the sternum is composed of three parts, but in later life these parts join firmly into one bone.

16. **The ribs** are twenty-four in number, twelve on each side. They are long and curved to form the walls of the chest. They are all fastened firmly to the vertebræ behind. In front, the seven upper, called the true ribs, are joined by cartilages to the sternum. The next three are united by cartilages to the true ribs. The lowest two have no front attachment. By this arrangement, the chest is more yielding in its lower portion than in the upper region.

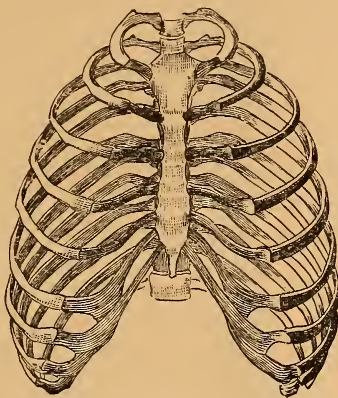


Fig. 5.
THE CHEST.

17. **The pelvis** is composed of large bones, that form a stout, basin-like frame. This frame bears the weight of the parts above, and supports the trunk upon the lower extremities.

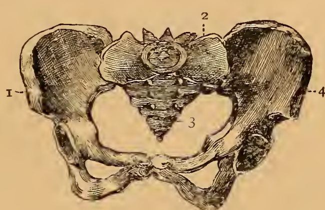


Fig. 6.
THE PELVIS.—1. Hip Bones. 2. Sacrum. 3. Coccyx.

18. **The Bones of the Upper Extremities.** — The clavicle, or "collar bone," is braced against the sternum in front, and the scapula, or "shoulder-blade," is placed on the back. These two bones unite to form the prominence of the shoulder and a shallow socket in which the head of the humerus is held. This makes the shoulder-joint. The humerus is the long bone of the arm. The ulna, the inner bone of the fore-arm, joins with the humerus to form the elbow. The radius is placed by the side of the ulna, in the

fore-arm. These two bones twist about each other in turning the hand over.[6] At the wrist there are eight pebble-shaped carpal bones, so united as to give great freedom of motion to the hand. The five metacarpal bones form the palm of the hand, and the fourteen phalanges form the fingers and thumb.

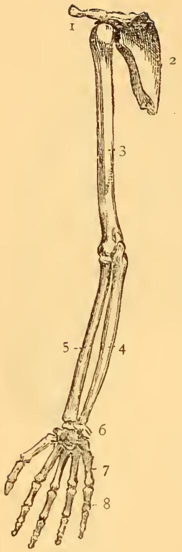


Fig. 7.

Upper Extremity.—1. Clavicle. 2. Scapula. 3. Humerua. 4. Ulna. 5. Radius. 6. Corpus. 7. Metacarpal. 8. Phalanges.

19. The bones of the lower extremities join the sides of the pelvis by the insertion of the head of the femur, or "thigh bone," in a deep socket of the pelvis. This forms the hip joint. The femur joins at the knee with the tibia, or "shin bone," of the leg. The patella, or "knee-pan," fits into the hollow of the knee in front. The tibia and fibula are placed side by side in the leg. At the ankle, these two unite with the seven tarsal bones to form the ankle joint. The tarsal and five metatarsal bones form the arch of the instep, and the phalanges form the toes.

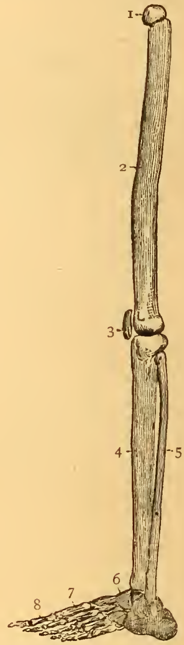


Fig. 8.

Lower Extremity. — 1. Head of Femur. 2. Femur. 3. Patella. 4. Tibia. 5. Fibula. 6. Tarsus. 7. Metatarsus. 8. Phalanges.

20. The Composition of the Bones.—The bones are composed of two kinds of matter: (1) a jelly-like substance, known as the animal matter, and (2) a hard substance, known as the mineral part. The bones of very

young persons contain much animal matter, and the bones of old persons consist largely of the mineral substance. It is by the combination of these two kinds of matter that the bones possess their great strength. The mineral part makes them hard, and the animal portion preserves their toughness and elasticity.[7] By burning a bone, the animal part is driven off by the heat, and the mineral portion is left in the form of a white, brittle body, resembling chalk. By placing a fresh bone in weak acid for a few hours, the mineral part will be dissolved, and the animal part will remain. The animal part thus left will have the shape and size of the original bone, but will be so soft that it may be tied in a knot.

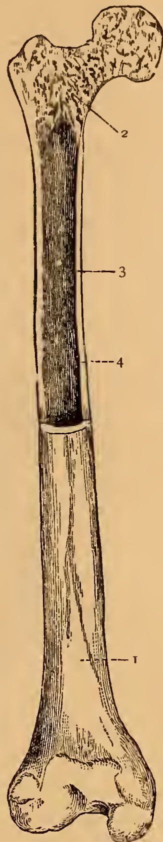


Fig. 9.

SECTION OF FEMUR.—1. External view. 2. Cellular portion at end. 3. Hollow in middle. 4. Thick shell of middle.

21. The Structure of the Bones.—The long bones are so formed that they are hollow cylinders. This shape gives them great strength without the use of much matter, and makes them sufficiently large without their being heavy. The outer part is a dense, hard shell, but toward the center the matter becomes more porous, and the middle is a hollow, filled with a fatty substance, called marrow. The ends are large, to render the joints strong. The outer shell of the end is thin, and the whole inner portion of the end is composed of numerous tiny cavities, separated by thin, bony partitions. These cavities are filled with fluid. By this means, the ends, though large, are not so heavy as if they were solid bone. Between the ends, the

shell of the bone is much thicker, so that these smaller parts may be strong also.

The bones are covered with a tough membrane, called the periosteum. This membrane protects and nourishes them. This tough cover, together with the many prominences and roughnesses on the bones, gives attachment to the soft parts (muscles) that move the bones.

22. **Minute Structure of the Bones.**—The bones are filled with myriads of tiny chambers, passages and cells. These openings permit nourishment to pass through the bones. See figures 10 and 11.

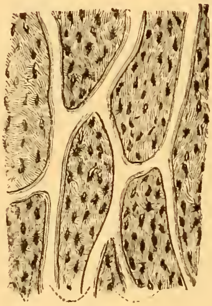


Fig. 10.

Longitudinal Section of Bone (microscopic).—1. Cells. 2. Canals. 3. Intercellular Substance.

Fig. 11.

Cross-Section of Bone (microscopic).—1. Cells. 2. Canals. 3. Intercellular Substance.

23. **Joints.**—The union of two or more bones is a joint. A joint may be formed for the purpose of binding the bones together firmly, as in the case of the sutures of the skull, or a joint may be for the free movement of the parts, as with the joints of the fingers; such unions as the latter are called movable joints. Movable joints are classified into: (1) hinge joints, such as the elbows and knees; (2) ball and socket joints, as in the case of the shoulder and hip joints; (3) compound joints, like the wrists; and (4)

pivot joints, such as the rotation of the radius about the ulna, in the fore-arm.

In movable joints, the ends of the bones do not touch each other. The ends of the bones are covered with a

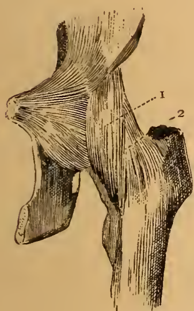


Fig. 12.

HIP JOINT.—1 and 2. Capsular Ligament.

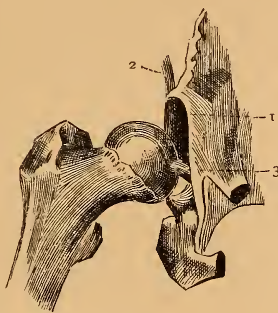


Fig. 13.

HIP JOINT, with Capsular Ligament cut away.—1. Margin of Socket. 2. Portion of Capsular Ligament. 3. Round Ligament.

layer of cartilage, which prevents the jar and wear that would occur if the ends of the bones rubbed together. The cartilage on each bone is covered with an exceedingly smooth membrane, called the synovial membrane. This membrane lines the whole inner surface of the joint. This membrane secretes a fluid between the surfaces that rub together, so that the joint moves with the greatest possible ease and smoothness.

The great strength of a joint is due to the enlarged ends of the bones, and to the ligaments that bind the bones together.[8] These ligaments are formed of dense, inelastic, fibrous tissue. They are fastened from bone to bone, over the joint, so as to inclose the two ends of bone in one band, or capsule. Besides this capsular ligament that surrounds the joint, other short ligaments, within the joint,

fasten the ends of bone together. So strong are the joints that the limbs, in breaking, will usually break elsewhere than at the joint.

24. **Injury to the Joints.**—The joints are often injured by violent twist or pressure. If the joint is so violently bent as to tear or damage its ligaments, the injury is called a sprain. A sprain produces great pain, and often requires a long time for recovery. The ligaments are slow to mend. The joint is usually weak for a long time afterwards.

When one end of a bone slips from its proper place in the joint, it is said to be dislocated, or "out of joint." Such an injury is most likely to occur to the round head of the humerus, in the shallow socket of the shoulder. To return the bone to its place, requires skillful stretching of the joint, and pressure upon the dislocated bone. Dislocation weakens a joint, so that the same misfortune is likely to re-occur with a joint once injured in this manner.

25. **Growth of Bones.**—The young bones are soft, and are composed in some cases of cartilage and in others of fibrous tissue. These soft bones have the proper shape and size. They become hardened by the deposit of mineral matter within them, until they are rigid bones. During life, the bones, like all other parts, are constantly undergoing change of structure. The old material is being removed, and new matter is taking its place.

26. **A broken bone** is repaired in the same manner in which the bone grows. At first, a watery fluid is poured out about the broken ends; this fluid thickens day by day, until it is jelly-like and fibrous in composition. This matter hardens by the deposit of mineral matter, so that by the end of about six weeks the broken parts are quite firmly reunited. The union is frail, however, for several months. Finally the place of fracture becomes firm, and is even more strong, in some cases, than are the other parts of the bone. In order that the repair of the broken bones

may proceed properly, they need to be held in position by stiff bandages. It is necessary, too, that the broken limb be kept quiet.[9]

27. **Hygiene of the Bones.**—The healthfulness of the bones is affected by the food.[10] If children are fed on diet that is deficient in bone-making substances, the bones do not become rigid and firm. Exercise strengthens the bones, by causing more blood to flow to them, and by forming the necessary deposit of matter in them for their growth. Great care needs to be taken not to deform the bones in early life by pressure and improper position. Injury is especially liable to occur to the bones of the chest by tight dressing, and to the spinal column by sitting or standing in stooped position. Habits and shapes acquired in this way in early life are scarcely to be remedied when the person grows older.

Broken bones and injured joints require patient care, and deserve the attention of a skillful physician.

NOTES.

1. **Skeletons of Animals.**—There are two plans of skeleton among animals: (1) In the higher animals, the frame-work is internal, with the muscles arranged about it, the whole covered with a soft, pliable skin, as illustrated in all vertebrates, such as mammals, birds, reptiles, and fishes. Their skeletons are much like the human skeleton. (2) The animals below the vertebrates have the skeleton, or hard frame-work of the body, on the outside. Such is the case with insects, crabs, lobsters, mollusks, etc. In these cases, the skeleton is a hardened skin; the muscles that move it are within.

2. **The teeth** are not included in the bones of the skeleton because they do not form a part of the frame-work. They resemble bone in structure and composition. They resist decay so perfectly that they are usually the last portions of the body to decompose. They are properly appendages of the skin, as are the nails and hair. They are treated of more fully under the organs of digestion.

3. **The skull bones** are formed of double plates, an outer and an inner, between which there is a packing of spongy bone. This arrangement gives them great strength in the resistance of fracture by blows. In many cases, the skull has been known to turn aside a pistol or rifle bullet rather than suffer it to enter the brain. In infancy, the sutures are large; in middle age, they are narrow, but distinct; in old age, they nearly disappear by the growth of bone.

4. **The pads of cartilage** between the vertebræ vary in thickness from one fourth to one half inch. These plates make the column elastic, so that the brain rests upon it without jar or shock. These layers diminish in thickness by pressure, so that the column may bend from side to side, or forward and backward. The pressure of the weight of the body during the day makes the plates thin, and the column as a whole shorter than it is after they have expanded during the night. For this reason a person is slightly taller in the early morning than at evening.

5. **The spinal column** curves forward in the neck, backward in the dorsal region, forward in the lumbar portion, and backward in the pelvis. Frequently the curve in the dorsal region is greatly increased by sitting and standing in a stooped position. Such deformity tends to injure the chest. The column in its proper form bends neither to the right nor to the left. Frequently curvature to one side occurs because of weakness or from ill position in sitting, standing, or lying. Such curvature, though small at first, is a very serious deformity, and needs the attention of a physician. It may be relieved by exercises that tend to straighten and strengthen the spinal column. The position in school, in sleeping, in sewing, in sitting, and in standing needs constant attention.

6. **The radius and ulna** are placed side by side in the fore-arm, so that, when the hand lies with the palm upward, the radius is on the outer side. The ulna joins with the humerus at the elbow, forming a hinge joint, the head of the radius being fitted into a ring or collar on the side of the ulna; at the wrist, the radius joins with the carpal bones, and the head of the ulna fits into a collar on the side of the radius. In turning the hand over, the ulna remains fixed, and the radius turns over it. By grasping the fore-arm with the hand, one may feel the motion of the bones as they twist about each other.

7. **Bones.**—It is the animal part of the bones that is used in the making of soups and jellies. This portion is extracted by boiling. Glue is made from the animal portion taken from the feet of slaughtered animals. The mineral part of the bones is used in mak-

ing manure. In some regions of the world, immense beds of fossil bones and other animal remains are productive of the most valuable articles for enriching the soil. Phosphorus, which was formerly much used for the preparation of matches, is obtained by the chemist from the bones of animals.

8. **The joints** are held together in part by the fitting of the ends of the bones to one another, and by atmospheric pressure. Especially is this true of the ball and socket joints. It is estimated that the head of the femur is held in the socket of the pelvis by the pressure of the air equal to eighteen pounds, a force sufficient to bear the weight of the whole lower extremity. The tendons that pass over the joints aid in holding the joints together.

9. **Broken Bones.**—In cases in which bones are broken, place the sufferer in the most comfortable position possible, and the broken part as nearly as may be in the natural shape, keeping the parts from moving. Call a competent surgeon at once. If no physician can be obtained, place the broken bones in their natural position by gently but firmly stretching and pressing the parts. Bind the broken limb, not too tightly, with such a bandage as will prevent change in the position, and keep the parts quiet. The broken limb should be kept in a natural form at all times until the broken bones are firmly united.

10. **Rickets.**—In cases in which children are ill-fed, they suffer from the disease called "rickets," in part, at least, because of the weakness and imperfection of the bones. In extreme cases of this kind, the bones are like wax. The lower extremities of very young children are frequently bowed outward at the knees before the bones are sufficiently strong to sustain the weight. Deformities of this kind should be carefully avoided.

Suggestive Questions.

Why are the bones hard? What makes them so? How is it they are almost as light as wood, but are much stronger? How do the bones of young persons differ from the bones of old people? Why are the broken bones of old persons difficult to repair? How do the sutures of the skull add to its strength? Why is the skull ovoid? What purposes are served by the cartilages between the vertebræ? Why are the bones of the lower portion of the chest most yielding? What elements in the structure of a joint give it strength? Why do the joints move so easily?

What is the cause of "round shoulders?" What service does the clavicle perform? If the clavicle is broken, how will the shoulder change in form? What gives the wrists and ankles such freedom of motion? Can you count the metacarpal bones of your hand? Can you feel the movement of the radius and ulna in revolving the hand? How is each kind of matter obtained from the bones? How are the bones affected by proper exercise? How do the bones grow?

Topical Outline.

Bones.

1. General character.
2. Number.
3. Arrangement.
4. Composition.
   a. Animal.
   b. Mineral.
5. Structure.
   a. Gross.
   b. Minute.
6. Joints.
   a. Design.
   b. Classes.
   c. Structure.
7. Growth and Repair.
8. Injury.
   a. Sprain.
   b. Dislocation.
   c. Fracture.
9. Hygiene.
   a. Effects of exercise.
   b. Effects of food.
   c. Deformity.

Bones of Skeleton.

1. Head.
   a. Skull.
      (1) Frontal—Front Part of Skull.................... 1
      (2) Occipital—Back Part of Skull.................. 1
      (3) Parietal—Walls of Skull....................... 2
      (4) Temporal—Temples.............................. 2
      (5) Ethmoid—Base of Skull......................... 1
      (6) Sphenoid—Base of Skull........................ 1
      (7) Ear Bones—Inside the Ear...................... 6......14
   b. Face.
      (1) Nasal—Bridge of Nose.......................... 2
      (2) Lachrymal—Tear Tubes into Nose................ 2
      (3) Vomer—Partition in Nose....................... 1
      (4) Turbinated—Walls of Nose...................... 2

(5) Malar—Cheek Bones 2
(6) Superior Maxillary—Upper Jaw 2
(7) Inferior Maxillary—Lower Jaw................ 1
(8) Palate—Roof of Mouth 2
(9) Hyoid—Base of Tongue .... 1......15

2. Trunk.

a. Spinal Column.

(1) Cervical Vertebræ—Neck.................. ... 7
(2) Dorsal Vertebræ—Back of Chest 12
(3) Lumbar Vertebræ—Back .... 5......24

b. Chest.

(1) True Ribs—Upper Part of Chest................14
(2) False Ribs—Middle Part of Chest 6
(3) Floating Ribs—Lower Part of Chest..... 4
(4) Sternum—Breast-bone........................ 1......25

c. Pelvis.

(1) Sacrum—Support of Column 1
(2) Innominata—Hips 2
(3) Coccyx—Below the Sacrum 1 4

3. Upper Extremities.

(1) Clavicle—Collar Bone 2
(2) Scapula—Shoulder Blade 2
(3) Humerus—Arm 2
(4) Radius—Fore--arm............................ 2
(5) Ulna—Fore--arm.............................. 2
(6) Carpal—Wrist........ 16
(7) Metacarpal—Hand............................10
(8) Phalanges—Fingers ....28......64

4. Lower Extremities.

(1) Femur—Thigh Bone 2
(2) Patella—Knee Pan............................ 2
(3) Tibia—Shin Bone 2
(4) Fibula—Brace of Tibia.................. 2
(5) Tarsal—Ankle................................14
(6) Metatarsal—Instep............ 10
(7) Phalanges—Toes..............................28......60

Total............. ... .206

See Plate I. for the bones forming the skeleton.

CHAPTER III.

THE MUSCULAR SYSTEM.

28. The parts surrounding the bones are soft. These soft, fleshy portions are the muscles. All the motions of the body are produced by the action of the muscles. The bones and joints are nicely adapted for motion, but require the muscles to move them. The muscles are precisely like the lean meat of the ordinary slaughtered animal. They are of a deep red color. Their peculiar property is that of contraction and relaxation. By contraction they become shorter; by relaxation they are made longer. By contraction and relaxation, they move the bones and other parts to which they are fastened. The muscles give beauty of outline and roundness of form to the body. The skeleton, which is repulsive and deathlike, is imbedded out of sight in the muscles.

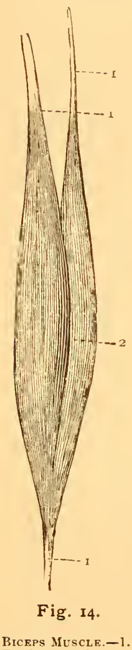


Fig. 14.

Biceps Muscle.—1. Tendon. 2. Muscular portion.

29. **The structure of the muscles** may be best studied by taking a long muscle, such as the biceps in the front of the arm.[1] This muscle is a long object, as shown in figure 14. The middle portion is somewhat cylindrical in form, while the ends are tapering. The

middle portion is fleshy, and the ends are fibrous. The middle portion, which is the muscular part, is composed of layers and bundles of fibers that extend lengthwise of the muscle. Each bundle is encased in a sheath of extremely tough, elastic tissue. The fibrous coats of the bundles extend to the ends of the muscle, and compose the tendons that attach the muscles to the bones. Each bundle is in turn made up of many tiny fibers of muscle, each fiber being covered with its delicate coat of fibrous matter, as is represented in figures 15 and 16. These minute fibers of muscle are composed of many little muscular cells. The cells are the part of the muscle that possesses the property of contracting and relaxing. By the influence of the nerves that lead to the muscles, each cell may be caused to shorten slightly. It is the shortening of all the cells that causes the muscle to become shorter and broader. The shortening of the muscle pulls the bone and causes motion. The whole muscle is enclosed in a dense layer of fibrous tissue, which also covers and forms a large part of the tendons. The tendons fasten to the bones by the union of the tendonous fibers with the periosteum and bone matter.[2]

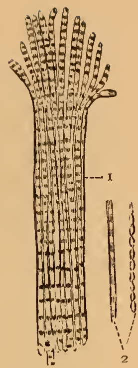


Fig. 15.

MINUTE MUSCULAR TISSUES.—1. A bundle of fibers torn to show the separate fibers, greatly magnified. 2. Detached fibers.

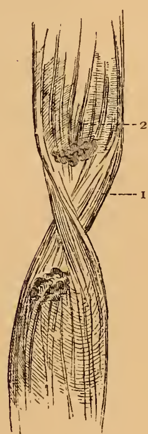


Fig. 16.

A SINGLE FIBER PARTLY BROKEN AND GREATLY MAGNIFIED.—1. The delicate fibrous cover unbroken. 2. The muscular substance within, separated.

30. The action of the biceps muscle may be felt by grasping the arm tightly while the fore-arm is extended. Now, as the muscle pulls the fore-arm up, the change in form may be felt as the muscle becomes short, full, and firm. In figure 17, we see

the muscle is long and relaxed, while the fore-arm is extended. In figure 18, the muscle is contracted and the fore-arm is drawn upward. The muscle is attached to the bone of the fore-arm near the elbow, so that a slight change in the length of the muscle causes much movement of the fore-arm.

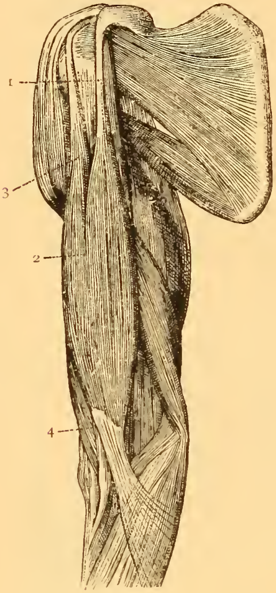


Fig. 17.

BICEPS MUSCLE RELAXED.—1, 3. Two heads of the muscle. 2. Muscular portion. 4. Tendon fastening to the fore-arm.

31. The muscles that close the fingers are placed on the front of the fore-arm, and those that open the hand are on the back of the fore-arm. The long, slender tendons that reach from these muscles to the fingers, pass along the wrist and hand to the joints of the fingers. By grasping the fore-arm, the muscles may be felt in their motion, and, by pressure on the wrist, the tendons may be felt like so many strong cords.

32. **Arrangement and Classes.**—The muscles weigh more than all the rest of the body. There are more than double as many as there are bones. They are usually placed in pairs, on opposite sides of the parts they are to move. Muscles that bend the joints are called flexors; such as straighten the joints are extensors. The muscles are of various shapes. On the body and head they are broad and flat, while on the extremities they are usually long and tapering. In some cases they are circular and ring-shaped. The heart and stomach are hollow muscles.

The muscles are either voluntary or involuntary. The voluntary muscles, such as those of the arm, are under the

influence of the will, and hence move as the person chooses. The involuntary muscles do not move by the choice of the person. The muscles of the heart are involuntary.

33. Exercise and Rest.—Each muscle requires intervals of work and rest. Relaxation is the resting, and contraction the working stage of the muscle, hence it is that each muscle alternately contracts and relaxes. Rest and sleep must intervene between seasons of work, to restore the wasted parts and to renew the energies. During sleep, the whole muscular system becomes relaxed. The will ceases to direct the voluntary muscles, and the involuntary system is reduced in energy, as is seen in the slower action of the chest and heart. During the waking hours, all is activity and wear, but, during the quiet season of sleep, the parts are built anew. The muscles of the chest, heart, and alimentary canal also gain rest during the day by performing their tasks in intervals of work, followed by corresponding rests. For instance, the drawing in of the breath, which is done by muscular action, is nearly equalled by the time of breathing out the air, which admits of muscular rest. The muscles may be relieved by change in employment, which calls into action other parts of the body. Such changes are often quite as beneficial as quiet rest. It has been recommended that the day be divided into three equal parts,—eight hours for vigorous work, eight

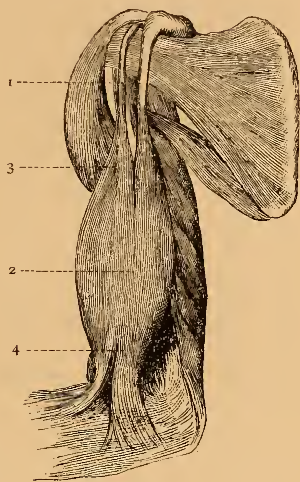


Fig. 18.

Biceps Muscle Contracted to Raise the Fore-Arm.—1, 3. Two heads fastened at the shoulder. 2. Contracting portion. 4. End fastened to the fore-arm.

for refreshment and recreation, eight for sleep. Probably no better division can be made. After a season of work, the muscles not only need rest, but require nourishment. Proper exercise increases the strength of the muscles by causing them to receive more blood and to take more nourishment. The strongest muscles are such as are most often used, provided they are properly rested. The weakest muscles are those that are used least. If the arm be bound for a season motionless to the body, its muscles become pale, soft, and weak, until, by continued disuse, the muscles become too feeble to raise the arm.

To be productive of good results, exercise needs to be taken at regular intervals, and at such times as do not interfere with digestion. Exercise should be taken in proper position, so that respiration and circulation may proceed rightly. It is best to exercise in the sunlight and pure air.

Very skillful movements of the muscles are acquired by repeated exercise of them under the direction of the mind.[3] The wonderful ease with which one walks, speaks, writes, and performs so many extremely complex movements, is due to constant effort and repetition.

NOTES.

1. **Composition of Muscular Tissue.**—It is impossible to determine the exact chemical composition of muscular tissue, since other structures, such as blood-vessels, nerves, and connective tissue, are so intimately blended with it. Berzelius gives substantially the following estimate of constituents:

Proper muscular substance, ...	15.8	per cent.
Gelatin, Albumen, Hematin, ...	4.1	"
Phosphate of Calcium and Albumen, .	.1	"
Alcoholic and watery extracts, . . .	2.8	"
Water and loss, ...	77.2	"
	100.	

2. Uses of the Muscles.—The muscles, under the control of the nervous system, perform many of the most important processes in the body. The muscles of the chest are engaged in respiration; the heart circulates the blood; the muscular walls of the stomach and intestines aid in reducing the food, and pass it through the alimentary canal; the muscles of the face are engaged in the movement of the jaws and eyes, and in the expression of emotions, such as pain, grief, and joy; and the muscular movements of the larynx control the action of the vocal cords in making the sounds of the voice.

3. The Hand.—The structure of the human hand, by which it admits of such diversity and complexity of movement, and by which it is so admirably adapted to perform the demands of the mind, is one of the best illustrations of the wonders of the human body. Attached at the ends of the long arms, they command a region of six feet in diameter, centered at the chest. The compound joints at the wrists give universality of motion; so, too, the thumb, supplied by many muscles, designed for its special motion, opposes itself with ease to any one of the fingers, or forms with them the hollow of the hand, or grasps against them the hand of another, or lays hold of any desired object. By muscular practice, in close union with thought, the hand becomes the forcible and significant instrument of expression by gesture, the rapid writer of words, the marvellously skillful organ of delicate touch by the musician. It is estimated that, in the rapid playing of a skillful pianist, no less than 950 movements of the fingers are made in a minute.

Suggestive Questions.

What elements of beauty do the muscles supply? What is their special purpose? What is their essential property? What causes the muscles to move? How may one feel the action of the muscles? What is the service of the fibrous tissues of the muscle? Why is the lean meat of an ox tough? How are the muscles attached to the bones? Where are the muscles that move the fingers in closing the hand? What advantage is there in their being so located?

Where are the muscles that move the jaw in chewing? How is the body held erect? How is a joint held so that it may be stiff? What rest does the heart have from labor? How may exercise be taken so as to increase strength? How may exercise weaken the muscles? How are the muscles attached to the bones so as to pro-

duce much motion by slight contraction? Why are the muscles not located on the bones they are to move? What kind of muscle closes the eye firmly? Why does the thumb possess such diversity of movement? Why should a person have change of employment?

Topical Outline.

Muscles.

1. Purpose.
   - *a.* To produce motion.
   - *b.* To give roundness of form.
2. Structure.
   - *a.* Muscular portion.
     - (1) Bundles and layers.
     - (2) Fibers.
     - (3) Cells.
   - *b.* Tendonous portion.
     - (1) Fibers.
     - (2) Attachment.
3. Essential property and action.
   - *a.* Contraction of cells.
   - *b.* Contraction of whole muscle.
4. Number and arrangement.
5. Classes.
   - *a.* On basis of form.
     - (1) Long.
     - (2) Broad.
     - (3) Circular.
     - (4) Ring-shaped.
   - *b.* On basis of direction of motion.
     - (1) Flexors.
     - (2) Extensors.
   - *c.* On basis of control.
     - (1) Voluntary.
     - (2) Involuntary.
6. Hygiene.
   - *a.* Effects of proper exercise.
   - *b.* Necessity of rest.

Names and Action of the Principal Muscles.

Head:

Occipito-Frontalis .... Elevates the eyebrows.
Corrugator Supercilii.. Wrinkles the brow in frowning.
Orbicularis Oculi..... Closes the eye-lids.
Levator Palpebræ..... Opens the eyes.
Recti (four in number) Move the eyeballs.
Temporal............ Raise the jaw in chewing.
Masseter............. Raise the jaw in chewing.
Orbicularis Oris...... Closes the lips firmly.
Buccinator........... Moves the cheeks.

MUSCLES.

THE STROBRIDGE LITH. CO. CINCINNATI.

Neck:

Sterno-Cleido-Mastoid...	Draws the head forward.
Digastricus	Draws the jaw down.
Scaleni	Bend the neck from side to side.
Constrictor	Moves the pharynx in swallowing.

Trunk:

Pectoral	Draws the arm forward.
Deltoid................	Raises the arm.
Terres Major...........	Lowers the arm.
Serratus Magnus........	Elevates the ribs.
Intercostal	Elevate the ribs.
Oblique	Form the walls of the abdomen.
Diaphragm	Separates chest from abdomen, and enlarges chest in breathing.
Erector Spinæ..........	Hold the spinal column erect.

Upper Extremities:

Biceps.................	Flexes the fore-arm.
Triceps................	Extends the fore-arm.
Pronator...............	Turns the fore-arm inward.
Supinator..............	Turns the fore-arm outward.
Flexor Carpi Radialis...	Bends the wrist forward.
Flexor Carpi Ulnaris....	Bends the wrist toward the ulna.
Extensor Carpi Radialis..	Extends the hand.
Extensor Carpi Ulnaris..	Extends the hand.
Flexor Digitorum	Closes the fingers.
Extensor Digitorum....	Extends the fingers.

Lower Extremities:

Glutæus	Moves the thigh backward.
Iliacus	Draws the thigh forward.
Psoas Magnus..........	Draws the thigh forward.
Rectus	Extends the leg.
Vastus	Extends the leg.
Biceps.................	Flexes the leg.
Gracilis	Flexes the leg.
Extensor Digitorum....	Flexes the foot and extends the toes.
Gastrochnemius	Extends the foot.

See Plate II.

CHAPTER IV.

THE SKIN.

34. **The Uses of the Skin.**—The skin forms a beautiful, pliable covering for the body. By the exceeding toughness of the skin, the tender parts beneath it are protected from injury. The nerves of the skin tell when an object touches us. The skin keeps the body from getting very warm or very cold. The skin aids in removing waste matter from the blood. Since the uses are so numerous and different, the structure of the skin is necessarily complex.

35. **The Structure of the Skin.**—The skin is composed of two layers. The outer layer is called the cuticle. The inner layer is called the cutis. The cuticle is fitted closely upon the cutis. See Fig. 19.

The cuticle is formed of tiny, flat cells, closely packed together in layers. These cells are dry and scaly on the outer surface of the cuticle, while at the base they are soft and growing. The outer cells are constantly wearing off by friction, and are being replaced by the new cells from below.[1] The outer portion of the cuticle is horn-like, and resists the action of many substances which would injure the tender cutis.[2] On the palms of the hands and soles of

the feet, where the skin is subject to much pressure, the cuticle grows hard and thick.[3] The cuticle has no blood-vessels, hence it does not bleed; it has no nerves, hence it is without feeling. At the base of the cuticle, there are grains of coloring matter, which give complexion to the skin.

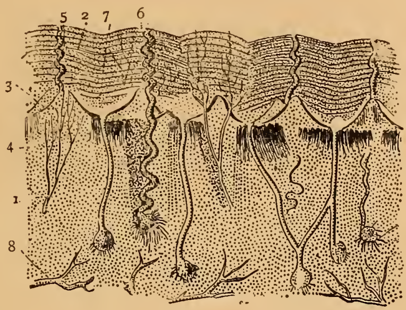


Fig. 19.

VERTICAL SECTION OF THE SKIN. (Microscopic).—1. Cutis. 2. Cuticle in layers. 3. Papilla. 4. Nerves of the Papilla. 5. Opening of Perspiratory Gland. 6. Perspiratory Gland entire. 7. Vessels for secreting coloring matter. 8. Blood-vessels.

36. The hair and nails are modifications of the cuticle, however much they may fail to resemble it at first sight.

The nails are formed of layers of cells that grow from a fold in the cuticle at the root of the nail, and that grow under the nail. These cells move forward toward the end of the fingers, so that the whole nail is renewed in about four months. The nails shield the ends of the fingers, preserve their sensitiveness, give firmness of grasp, and aid in picking up small objects.[4] See Fig. 20.

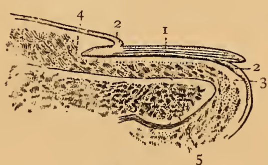


Fig. 20.

VERTICAL SECTION THROUGH THE FINGER END.—1. Nail. 2. Cuticle. 3. Cutis. 4. Groove in Cuticle at the root of the Nail. 5. Bone.

The hairs are formed of cells from the cuticle. Each hair grows from the top of a tiny bulb at the base of a deep sac in the skin. This sac is formed by a depression of the cuticle far into the cutis. The hair is cylindrical. It has a hollow throughout its length. This hollow is filled with air in the outer portion of the hair, and with liquid at

its base. The coloring matter of the cuticle gives color to the hair. Each hair is nourished at its inner end by the blood-vessels of the cutis. The hair grows from below, constantly pushing itself out through the sac. The hair is designed as a protection to the parts which it covers. When properly cared for, the hair is an element of beauty to the person.[5] See Fig. 21.

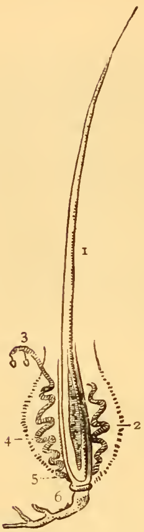


Fig. 21.

A Hair.—1. External part. 2. Sac in skin. 3. Surface of Cuticle. 4. Sebaceous membrane. 5. Bulb at base. 6. Nourishing vessel.

37. **The cutis,** or true skin, is exposed to view when the cuticle is removed. This part is thicker than the cuticle. The cutis is composed mainly of fibrous tissue, so interwoven as to make a very dense, tough mass. Leather, as it is prepared from the skins of animals, shows how largely the skin is composed of tough fiber. Through this tough body of the cutis, there is distributed a network of minute blood-vessels, and the surface is thickly set with nerves. These blood-vessels and nerves are so numerous, that the point of a needle can scarcely enter the cutis without drawing blood and causing pain.

38. **The Glands of the Skin.**—Located in the outer portion of the cutis, there are many small glands. These glands secrete an oily substance into the cuticle, and upon its surface. These are the sebaceous glands. They are designed to supply the skin with such matter as will preserve the softness of the skin, and will form a glossy dressing for the hair.

More deeply imbedded in the cutis, there are great numbers of very small tubes that are coiled into knots or glands

near the base of the cutis. These are the perspiratory glands. They receive the water from the blood, and pour it out on the surface of the skin. This water is called sweat or perspiration. The perspiration consists almost wholly of water. It contains minute quantities of salt and other impurities from the blood.

39. **Regulation of Temperature.**—The evaporation of the perspiration cools the skin. When the body becomes too warm, the pores of the skin open wider, so that the blood flows freely to the surface. Then the perspiratory glands receive more than the usual quantity of water from the blood. They pour this water out on the surface of the warm skin. This water or perspiration evaporates, and cools the skin and the blood that flows through it. In this way, the warmth of the entire body is kept from rising too high. One may readily observe how evaporation cools the skin, by wetting one hand in warm water, and moving it rapidly through the air until dry. The hand that was wet soon becomes cooler than the other.

When the body is exposed to cold, the pores of the skin close, and prevent much perspiration, so that the surface of the skin may be dry; this helps to keep the body warm.

40. **Hygiene of the Skin.**—The skin will absorb many substances that are placed upon it. These substances make their way through the walls of the blood-vessels, and by entering the blood are borne through the system. Water and some liquid foods will enter the blood in this way in extremely small quantities. It is frequently by this action of the skin that poisons enter the blood, that contagious diseases are received by touch, and that medicines applied to the skin affect the parts beneath.

The proper action and condition of the skin are necessary for the preservation of the health of the entire body. This leads us to consider the most direct means by which

the skin is affected. Two of these are: (1) The condition of the clothing, and (2) the cleanliness of the skin itself.[6]

41. **Clothing.**—The clothing, especially that which is worn next to the skin, needs to be clean and to be changed frequently. The underwear needs to be changed for two reasons: (1) To allow it to dry; (2) to keep it from being filled with effete matter from the body. When the clothing becomes filled with this waste matter, it prevents the skin from taking this poisonous waste matter from the blood. The underwear worn during the day should be laid off at night, so that these garments may be freely aired. The bedding should be exposed to the light and air during the day. Clean under-clothing, by its friction against the cuticle, and by its tendency to absorb the moisture of the surface, aids greatly in causing a healthful action of the skin.[7, 8]

42. **Bathing.**—The skin itself becomes unclean in the following ways: (1) By the excess of oily matter from the sebaceous glands; (2) by portions of the perspiration left on it; and (3) by the dust that adheres to it. These various substances should be removed by bathing. For persons in good health, a daily cool bath will prove both pleasant and beneficial, if the following be observed: (1) The bath should be accompanied by a thorough rubbing of the skin with a rough towel; (2) this should be followed by brisk exercise. For persons who are less robust, a bath once or twice a week, in a warm room, with tepid water, followed by thorough drying and rubbing, may be sufficient. Every one needs to take at least one warm bath every few days. Soap should be employed to remove the greasy matter that fills the pores and covers the surface. A harsh cloth or flesh brush should be used to detach the old scales of the cuticle. A person is in no danger of suffering from cold or chill who takes his bath in a room heated to summer temperature, using water that is pleasantly warm,

if he will thoroughly dry and chafe the skin until it becomes reddened, and glows with warmth. Brisk exercise may follow, as a means of causing continued flow of blood to the surface and extremities. By giving proper attention to the bath, and by wearing clean, warm, dry clothing, the skin may be kept in healthy condition.[9]

43. **Burning.**—The most common, as also one of the most painful injuries to the skin, is caused by burning or scalding. If the burn is deep, it will cause both the cuticle and cutis to be removed, and make a wound that will require a long time for recovery. Such an injury needs to have the air excluded from the part by some simple dressing, and to be kept clean and quiet, so that the skin may renew itself. Usually, in a burn, the cuticle only is raised in blister, which produces acute pain for hours after the occurrence. To relieve the burning pain, it is necessary to exclude the air from the burn. By submerging the burned part in cold water, or by wrapping the part in a bandage that is kept wet, or by coating the part with water and flour, the pain is readily relieved. A new cuticle soon begins to form next to the cutis, so that after a day's time or more the surface is covered and the injury is cured.

Notes.

1. **The Cuticle rapidly Renewed.**—The rapidity with which the cuticle is removed is shown by the short time that stains remain upon the skin. The whole cuticle is renewed within a few days.

2. **Protecting Power of the Cuticle.**—The protecting power of the cuticle is illustrated by placing the hand in brine, weak lye, or acid. The cuticle resists the action of these substances, but, if there is the least crack or scratch in the cuticle, the cutis is caused to burn and smart by the contact of these fluids. Poison of almost any ordinary kind may be handled with comparative safety if the cuticle is entire, whereas poison is readily absorbed if the cutis is exposed. Doubtless, the cuticle often protects the body from becoming poisoned.

3. **The Cuticle Thickened.**—The cuticle frequently becomes greatly thickened by pressure and friction, so that it irritates the cutis beneath and causes pain. Corns are produced in this manner upon the feet by tight shoes. To remove the corn, soak it in hot water, and pare off the thick cuticle with a sharp blade. Avoid the pressure, and the corn will not return.

4. **The nails** require much care in order to keep them in proper condition. By frequently using a stiff brush upon them at the time of washing the hands, the folds of the skin at the edges and roots of the nails may be readily cleaned, while a sharp knife may be used to pare away the out-growing ends, and to remove the matter from beneath them.

5. **The hair** is abundantly supplied with a natural dressing of oily matter from the skin, so that artificial pomatums are altogether needless. Unless much care is exercised in keeping the scalp clean, it becomes offensive with the excess of oily matter and the dust that adheres to the skin and hair.

6. **Perfumes and Cosmetics.**—Perfumes may for a time overpower the odors that arise from an unclean body, but they can not in any sense serve the purposes of warm water in cleaning the skin, and of clean clothing in gracing the body. Cosmetics give the skin of the face an unnatural hue by their poisonous effects upon its tissues. Liquid arsenic is at the same time the most effective cosmetic and the most horrid poison. Ugly sores and blotches are liable to result from the use of such substances.

7. **The clothing** is designed to protect the body against the cold of winter, the heat of summer, and the dangers resulting from sudden changes in temperature. Loose and porous clothing is warm. Woolen fabrics are most valuable in this respect. Garments made of wool are poor conductors of heat, and, when worn next to the skin, do not allow the warmth of the body to escape through them. They are not easily moistened by the perspiration, and do not readily give it off by evaporation. Flannel worn next to the skin is, for the reasons just given, an excellent protection against sudden changes in temperature. In a climate such as exists in the central part of the United States, it is best to wear a suit of flannel under-clothing at all seasons of the year, unless it be during the midsummer. In winter, these suits should be increased until they will of themselves keep the body warm. Especially do the extremities need abundant protection by woolen clothing, in regions in which the winters are severe. For the milder seasons, cotton fabrics may replace the woolen. They more

readily absorb the moisture of the skin, and lose it by evaporation. The coolest clothing is linen, which is particularly adapted to relieve the skin of its moisture, and to repel the direct heat of the midday sun in the summer season. The rubber overdress is most valuable in preventing the clothing from becoming wet by rain or snow; and the rubber overshoes are useful for keeping the feet dry in case of mud and sloppy walks. These rubber articles should be laid off upon coming in-doors, as they prevent the proper escape of the vapors of the body.

8. **Air and Sunlight.**—The healthy action of the skin is decidedly affected by the wholesome influence of fresh air and sunlight. Exercise in the open air, and in the strong light of the sun, gives such strength and vigor as will make the pale and puny indoor-dweller robust and rugged. Outdoor sports, brisk walks, rides, and all kinds of work under the open sky will invigorate every tissue of the body, purify the blood, quicken digestion, and enliven the whole body and spirit. The rooms in which persons sleep, and those in which they spend much time during the day, need the direct rays of the sun. Sunlight is the vivifying force of the entire organic world.

9. **Colds.**—One of the most common afflictions is that of "taking cold." What is known as a "cold" is usually a congestion and inflammation of the throat and lungs, or of some other internal membrane. Usually this condition is caused by wearing damp clothes, by getting the feet wet, by the sudden cooling of the skin after exercise, by sitting or lying on the damp ground, by undue exposure of the extremities, by exposing some part of the body to a current of cold air, or by chill in some other way. In all these cases, the cause is one that affects the skin so that the blood current through it is chilled, and the blood is sent in undue quantities to the delicate surfaces within. Much may be done to relieve a "cold" by applying warmth to the extremities, and by such treatment as will relax the skin and excite it to an active condition of excretion and circulation.

Suggestive Questions.

How does the skin protect the body? Why does it not break and crack by bending? Why is it so complex in structure? How does the cuticle protect the cutis? What are the uses of the hair and nails? How do they grow? How are the feathers of a bird like hair? What is leather? Might it be made from human skin? What is the use of the sebaceous glands? How is the skin warmed?

Why does the skin become red with exercise? How is the skin cooled? How does wet clothing tend to produce chill? What is the principal matter that the skin takes from the blood? Why is poison sometimes received by touch? What part of the clothing needs special attention as to cleanliness? Why should a person not sleep in the underclothing worn during the day? Why does every person need to bathe? How may a person prevent chill from bathing? How relieve the pain of a burn? What are the purposes of the skin?

Topical Outline.

1. General Description.
2. Structure.
   a. Cuticle.
      (1) Appendages.
         (*a*) Nails.
         (*b*) Hairs.
   b. Cutis.
      (1) Fibrous tissue.
      (2) Blood-vessels.
      (3) Glands.
         (*a*) Sebaceous.
         (*b*) Perspiratory.
      (4) Nerves.
3. Purposes.
   a. Protection.
   b. Regulation of temperature.
   c. Removal of waste matter.
   d. Organ of touch.
4. Hygiene.
   a. Injury by absorption.
   b. Condition of clothing.
   c. Bathing.
   d. Treatment of burn.

CHAPTER V.

THE TEETH.

44. **Composition of the Teeth.**—The teeth are exceedingly hard bodies, set firmly in the bones of the jaws. They are designed to cut and grind the food.

Each tooth presents three parts: (1) The crown, which is the portion seen above the gums; (2) the roots, the portion imbedded in the jaw; (3) the neck, or middle portion surrounded by the gums.

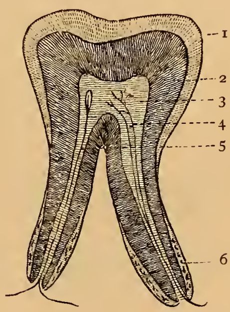


Fig. 22.

VERTICAL SECTION OF A TOOTH.—1. Enamel. 2. Dentine. 3. Pulp. 4. Blood-vessel. 5. Nerve. 6. Fibrous cement.

A vertical section (Fig. 22) shows that the main substance of the tooth is a hard, bone-like matter, known as dentine. Common ivory is dentine. The crown is covered with a layer of dense, hard substance, called enamel. The enamel is much like flint or glass, and is the hardest kind of matter in the body. The inner portion of the tooth is soft and pulp-like. In this internal portion are found the nerves and blood-vessels of the tooth. The nerves and vessels enter through small openings in the ends

of the roots. The sockets in the jaw, and the roots that fit into them, are covered with a packing of fibrous matter that holds the teeth firmly in their places, and which serves as a cushion to prevent jar from biting hard food. The gums are composed of fibrous tissue, covered with a layer of mucous membrane. They aid in holding the teeth in place.

45. Sets of Teeth.—There are two sets of teeth: (1) temporary, and (2) permanent. The temporary teeth are twenty in number, ten in each jaw. The front eight are flat and sharp, called incisors, or cutting teeth; then four pointed, or cuspid teeth; and back of these, eight grinding, or molar teeth. This set begins to appear when the child is but a few months old, and are all present by the end of the third year. From the fifth to the eighth year they are gradually removed by a second set, that grow beneath them in the jaw, so that the teeth of the first set become loose, and are easily removed.

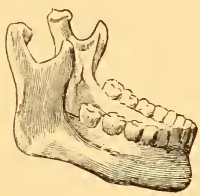


Fig. 23.
LOWER MAXILLARY BONE.

The second, or permanent set, are larger and stronger than the first, and are designed to serve during the remainder of life. There are thirty-two in this set, sixteen in each jaw, as follows: eight incisors, with four cuspids, back of which are eight bicuspids (two pointed), with twelve molars far back in the mouth. Figs. 23 and 24.

Fig. 24.
FULL PERMANENT SET. SEEN IN FRONT.

46. Care of Teeth.—The teeth require careful attention in order that they may be preserved in a sound condition, free from decay and pain, and that they may, by their beautiful, pearly appearance, add so much to the beauty of the face in time of conversation.

To clean the teeth, it is well to brush them freely once or twice each day with a soft brush and water. To more effectually remove any deposit that may be upon them, occasionally employ powdered charcoal or finely pulverized chalk upon the brush. Even with this care, the saliva of the mouth will in many cases deposit a yellow crust of tartar about the edges of the gums, which needs to be removed frequently, else it will injure the enamel, and cause the teeth to appear unsightly. A quill or wooden toothpick should be used after a meal to remove any matter left between the teeth. It injures the teeth to pick them with pins.

The enamel of the teeth, while it is extremely hard, and resists the action of almost any substance, is quite easily cracked or broken. Once injured, it is never restored, hence the great care that needs to be exercised. It may be injured by any of the following simple means: by sudden changes in temperature, by very hot or cold food, by breathing very cold air through the mouth, and by cracking nuts between the teeth.

When the enamel is removed, decay of the dentine sets in, and the tooth soon presents a cavity. The decay, as it reaches the nerves within, causes pain, and if not stopped it will destroy the tooth. For this reason the teeth need to be closely watched, and as soon as a cavity is detected it should receive the attention of a skillful dentist, and be properly filled with gold or some other substance that will prevent farther decay.

By attention to cleanliness and repair, the teeth may be preserved during the life of the person, and the individual escape great pain and discomfort; besides, too, the general health will also be greatly enhanced. While the teeth add so greatly to the beauty of facial expression, they serve also as important organs in the distinct and natural articulation of sounds.

Suggestive Questions.

How are teeth adapted to their purposes? How is the crown prepared to resist wear and the action of substances? How are the teeth held in position? What causes the temporary teeth to become loose? At what age are the temporary teeth all removed? What kinds of teeth are found in the permanent set that are not in the temporary? How are the teeth injured? How may they be kept clean? What necessities are there for keeping them clean? What substance is it difficult to remove from them?

How should a cavity be treated? Why should a cavity be filled early? What is tooth-ache? What uses do the teeth serve beside that of chewing the food? How may their condition affect the general health?

Topical Outline.

The Teeth.

1. General Character.
2. Purposes.
3. Structure.
   a. Parts.
      (1) Crown.
      (2) Roots.
      (3) Neck.
   b. Composition.
      (1) Dentine.
      (2) Enamel.
      (3) Pulp.
4. Sets.
   a. Temporary.
   b. Permanent.
5. Preservation.
   a. Necessity of cleaning.
   b. Method of cleaning.
   c. Causes of fracture.
   d. Treatment of cavity.

CHAPTER VI.

FOOD.

47. All substances that nourish the body are food. Every one is familiar with hunger and thirst. These feelings are demands for food and drink. Food is required for the growth of the body, to maintain the warmth, and to repair the wastes caused by exercise.[1]

Food is obtained from minerals, plants, and animals. The most nourishing food is obtained from plants and animals.

48. **The mineral substances** that in any way serve as food, are as follows: (1) Water, which is supplied in the usual forms of drink, and is also part of many kinds of foods, especially fruits; (2) Various salts, such as common table salt, lime salts, iron salts, and other mineral substances. These are required to build up the teeth, bones, and some other parts. The salts that are taken as food are dissolved in the water we drink, and are contained in many of the grains we eat.

49. **The organic substances** that are used as food are divided as follows: (1) Albuminoids, (2) Fats, (3) Sugars.[2]

Albuminoid foods are much like the various tissues of the

human body. They seem best suited for nourishing the body, while at the same time they serve in part to produce its warmth. The most important articles of this group of foods are albumen, fibrine, and caseine. White of egg contains large quantities of albumen. Lean meat and wheaten bread contain both albumen and fibrine. The curd of milk is caseine. Persons who take much muscular exercise require food of this kind.

Fats are foods that are like the fatty portions of the body. The chief use of the fats is to keep the body warm. They serve somewhat to nourish the tissues and to preserve their strength. This kind of food is supplied by fatty meats, butter, kernels of nuts, and many oily grains and seeds. This kind of food is needed in Arctic regions, and during the winter seasons, to keep the body warm. The Esquimo delights in eating animal fats; to him oils and tallow are delicious articles.

Sugars include sugar, starch, and gums, and compose a large portion of the ordinary foods. These substances are found abundantly in corn, rice, wheat, potatoes, and ripe fruits. They serve admirably both to nourish and to warm the body. Observation and experience indicate that foods of this kind are to a great extent the proper diet for the people who live in the temperate regions of the earth.[3] Fatty foods serve best for a frigid climate, grains for the temperate, and ripe fruits for torrid latitudes.

A plain diet of nutritious food is better than one of elaborate mixture. A few articles eaten together are usually better than a meal made of a single substance, because one kind may not contain all the elements needed to nourish the whole body.[4] Bread made of wheaten flour, or of the meal of other grains, eaten with ripe fruits, forms a safe combination of substances. Lean meat of beef, eggs and milk, served with grains, tubers, and fruits, are nutritious and wholesome.[5]

50. **Drink.**—The proper drink is pure water. Water is required in the system to preserve the moisture and softness of the various tissues. Many parts of the body are largely composed of water; thus, the blood is mainly water, and the nerves and muscles are three fourths water; even the teeth are one tenth water. Men can survive only for a few days without water, but they can live for many weeks without solid food.

If the water used for drinking purposes is not pure, it should be filtered or boiled. By filtering it through charcoal, the solid impurities and bad odors may be removed. By boiling it, the germs of disease that it may contain will be killed. Many cases of typhoid fever, and other serious diseases, arise from drinking impure water.

Milk is both drink and food. Milk from unhealthy animals should never be used.

Tea and coffee, as commonly added to water for diet-drinks, are needless and expensive, and when used in excessive quantities they are injurious to the human system. Much headache and indigestion result from the effects of these substances. They do not aid in nourishing and warming the body. Their influence is that of excitement and stimulation.[6]

51. **Alcoholic Drinks.**—Cider, beer, wine, and whisky contain alcohol.[7] It is the alcohol they contain that gives to them their peculiar intoxicating properties. While cider and beer are composed mainly of water, and contain small quantities of nourishment in the form of sugar, the alcohol they contain leads to their use as drinks. The alcohol in such beverages does not act either as a food or drink. It creates thirst. It does not satisfy hunger. Its action on the muscles and nerves produces excitement and inflammation. It tends to disorganize the blood, so as to produce diseased conditions of the heart, liver, and brain. Some of the most serious consequences that can occur to either mind

or body, to health or character, result from the use of drinks containing alcohol. Persons who use such beverages acquire a craving for alcohol that often leads to the almost complete loss of their self-control, so that they have little or no power to resist temptation to drink such beverages in excess. In all of their forms, alcoholic drinks are too dangerous to be used as beverages. Alcohol is a medicine, not a food or drink. Medical writers, without exception, class alcohol as a poison.[8]

52. **Cooking** is designed: (1) To render food more easily digested, (2) to develop its flavors and make it more inviting to the senses, and (3), especially with meats, to destroy any germs of disease that may be in the food. The more simple and plain the manner of cooking, the more fully are these ends attained. When foods are boiled together in a promiscuous manner, or fried so that grease is thoroughly mixed with them, or seasoned with much salt and spices, they are rendered less easily digested. Roasting and baking usually prove to be the best methods of cooking.

53. **Hygiene.**—Health, as determined by food, requires: (1) That the articles used shall be sound and fresh; (2) that the food shall be suited to the season of the year and manner of life of the individual; and (3) that ease of digestion shall not be prevented by bad cooking.

Health requires that particular attention shall be given to the purity of the water employed for drink. The following rules should be carefully observed:

Avoid shallow wells, and such as are near vaults and sewers.

Use no water that will produce a scum when boiled.

Protect cisterns and wells from receiving surface water.

Use no water having a disagreeable odor or taste.

Water from springs or deep wells, and filtered rain-water, are the safest to use.[9]

NOTES.

1. **Quantity of Food Needed.**—The kind and quantity of food needed daily vary with the age, sex, occupation, and health of the person. It is estimated that a healthy man requires daily about one and two thirds pounds of oxygen from the air, four pounds or less of water, and about two and one third pounds of solid food, making about eight pounds during twenty-four hours.

2. **Composition of Foods.** — Animal foods furnish albuminoids and fats, in 100 parts, as follows:

Eggs	Albuminoid	14.	Oil	11.
Beef	"	8.	"	30.
Pork	"	4.5	"	50.
Cheese	"	29.	"	30.
Butter	"	1.	"	88.
Milk	"	4.	"	4.

Vegetable foods produce the three classes of foods about as follows, in 100 parts:

Oat Meal	Albuminoid	16.	Starch	63.	Oil	1.
Corn Meal	"	9.	"	65.	"	5.
Wheaten Flour	"	11.	"	74.	"	1.
Rice	"	8.	"	76.	"	1.
Beans	"	23.	"	52.	"	2.
Potatoes	"	2.	"	15.	"	0.

3. **Flesh food** is usually quite easily digested, and yields a ready supply of energy to the consumer; it does not, however, serve the purposes of great endurance as fully as the grain foods do.

4. **Mixed Diet.**—The inhabitants of frigid zones live almost exclusively on fats; some mountain tribes in central Asia live on flesh alone; one third the population of the globe live chiefly on rice; inhabitants of torrid zones live principally on fruits. In a varied climate, such as that of the central United States, and with a class of people who live such active lives, it is best that the diet should not be confined to one article. No one kind contains all the elements needed for nourishment.

5. **Plain Diet.**—The tendency, usually, is to depart from a plain and simple diet, and to resort to various mixtures, made palatable by artificial flavors. Such mixtures are often less nourishing and less easily digested than the more simple foods.

6. Tea.—Mild solutions of tea tend to produce pleasant exhileration and a temporary feeling of rest. This action is due to the stimulating effects of the *theine* and tannic acid which it contains. Continued use of strong solutions of tea causes headache, indigestion, enfeebled action of the heart, and derangement of the nervous system.

Coffee produces effects similar to those of tea. Continued use of strong coffee produces sleeplessness, headache, and indigestion. Its stimulating effects are due to the *caffeine* and essential oils it contains.

7. Alcoholic Beverages.—The following classification of alcoholic beverages shows the percentage of alcohol they contain:

ALCOHOLIC BEVERAGES,	Fermented,	Cider	3 to 10 per cent.
		Beer	3 to 10 "
		Ale	6 to 10 "
		Claret	7 to 9 "
		Champagne	5 to 13 "
		Madeira	16 to 25 "
		Port	16 to 25 "
	Distilled,	Rum	60 to 70 "
		Whisky	50 to 60 "
		Brandy	50 to 60 "
		Alcohol, ordinary	75 "
		Alcohol, absolute	95 "

8. Alcohol does not Nourish.—That alcohol does not serve to nourish the body is shown by the following contrasts:

A true beverage slacks thirst, and furnishes water to the tissues.	Alcohol produces thirst, and takes water from the tissues.
Food is nutritious substance; it enters the blood in a new guise; it satisfies hunger; it furnishes material for rebuilding the tissues.	Alcohol is innutritious; it enters the blood unchanged; it does not relieve hunger; it furnishes no material for rebuilding the tissues.
Heat-producing articles finally increase the temperature of the body, and the amount of carbonic acid exhaled.	Alcohol finally lowers the temperature of the body, and diminishes the amount of carbonic acid exhaled.

9. **Water Purifiers.** — Filters remove bad odors and harmful substances from impure water, by bringing the water in contact with charcoal. The charcoal absorbs the impurities. Boiling drives off the gases and coagulates the organic impurities. If a scum rises on water when it is boiled, the water contains organic matter and ought not to be used without being boiled. Salts are taken from water by causing the water to pass off in the form of steam. Steam from salt water is fresh. Rain-water is evaporated from salty seas.

Suggestive Questions.

Why is food required? What foods seem best suited for man? What substances are derived from the mineral kingdom? How do organic foods differ in character? What common articles supply albuminoid foods? What supply fats? What supply sugars? What seems to be the purpose of fatty food? Why does the Arctic inhabitant relish fat? How do the grains seem to be adapted to temperate regions?

What grains afford the best food? Why is it not well to live on one kind of food? Why is it not best to use a great variety of foods? What common articles eaten together form a suitable diet? Why do we eat butter with bread? What is the proper drink? What is the effect of tea and coffee? What is the nature of cider, beer, and wine? Why should a person not use these drinks? Why do we cook food? How is health determined by food? What injunctions are given concerning water?

Topical Outline.

Food.

1. Definition.
2. Purpose.
3. Sources.
4. Classes.
   a. Mineral.
   b. Organic.
      (1) Albuminoids.
         (*a*) Albumen.
         (*b*) Fibrine.
         (*c*) Caseine.
      (2) Fats.
      (3) Sugars.
5. Drink.
   a. Water.
   b. Other beverages.
      (1) Tea.
      (2) Coffee.
      (3) Alcoholic drinks.
6. Cooking.
7. Hygiene.

CHAPTER VII.

DIGESTION.

54. The process by which the food is prepared to become the nutrient part of the blood is called digestion. The parts of the body by which the food is thus prepared are called the digestive organs.

55. **The Alimentary Canal.**—Digestion is performed in a long, worm-like tube, called the alimentary canal. The alimentary canal begins at the mouth. It extends through the entire length of the trunk of the body. This canal is formed of three coats or walls. The inner wall is like the lining of the mouth. This inner coat is soft and moist, and is called the mucous membrane. The middle coat is muscular. The outer coat is smooth and soft.

Certain parts of the alimentary canal have received special names. The opening back of the mouth is the pharynx. The straight tube, about nine inches long, leading downward from the pharynx is the esophagus. At the lower end of this tube is an enlargement of the canal, forming a pear-shaped sack. This sack is called the stomach. It will hold about three pints. Connected with the stomach is a winding tube an inch or more in diameter and about twenty-five feet in length. This tube is called the intestines.

56. **Mastication** is performed in the mouth. The food is held between the teeth by the lips, cheeks, and tongue,

and is turned over and over by them. The strong muscles upon the sides of the head cause the teeth to cut and grind the food to pieces. At the same time the food is thoroughly moistened by the saliva which flows into the mouth from the three pairs of salivary glands. These glands are located as follows: (1) the parotid glands, just below and in front of the ears, (2) the sub-lingual, under the tongue, and (3) the sub-maxillary, under the jaw. Each of these glands is composed of a mass of tiny sacks and tubes, as represented in Fig. 25. The presence of food in the mouth causes these glands to take watery fluid, called saliva, from the blood and to pour it into the mouth.[1] The use of the saliva is to wet and soften the food so that it may be easily swallowed. The saliva also helps to dissolve the starchy part of the food and turns it to sugar.[2] This is why wheat grains, when chewed a short time, taste sweet. When the food is ready to pass from the mouth, it is pressed far back on the tongue, and is passed from sight and control into the pharynx. It then passes into the esophagus. In the esophagus, the muscular fibres above the food contract, and those below it relax, so that the food is swallowed into the stomach.[3]

Fig. 25.
Salivary Gland with its duct.

The importance of proper mastication is evident, because no other part of the alimentary canal is designed to cut and grind the food. The more thoroughly the food is chewed and mixed with saliva, the more readily it is digested. Then, too, thorough mastication develops the flavors of the food and makes the saliva flow more freely. By proper chewing, the whole mass becomes sufficiently moistened, so that it is unnecessary to drink much water or other fluid at the time of eating, to "wash the food down." Much liquid taken with the food dilutes the saliva and juices of the stomach,

so that digestion is thereby weakened. Food that is thoroughly chewed is properly started in the process of digestion.

57. Stomach Digestion.—The stomach is placed just below the diaphragm, in the upper part of the abdomen. It lies across the body, with the large end toward the left side. Fig. 26 represents the stomach and liver as they lie opposite each other across the body, the stomach occupying the left,

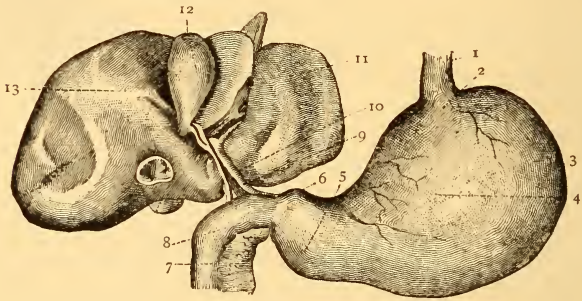


Fig. 26.

STOMACH AND LIVER.—1. Esophagus. 2. Cardiac entrance. 3. Large end of stomach. 4. Central portion. 5. Small end of stomach. 6. Pylorus. 7. Portion of Pancreas. 8. Duodenum. 9. Gall duct. 10. Hepatic artery. 11. Left lobe of liver. 12. Gall bladder. 13. Right lobe of liver.

and the liver, the right side. The liver is represented as turned upward, to show its under surface. The esophagus leads into the stomach from above, through an opening called the cardiac orifice. The small intestine begins at an opening at the small end of the stomach, called the pylorus (gatekeeper). These openings are guarded by bands of muscles, which keep the openings closed so as to hold the food in the stomach for the proper length of time.

When food enters the stomach, this organ is excited, and arouses from a quiet condition to one of activity. The blood flows to it in increased amount, so that its inner coat turns from a pale color to a deep red. The lining membrane becomes filled with the blood that flows into its minute blood-vessels. In this inner coat there are multitudes of

tiny glands, called gastric glands. When the blood flows freely to the stomach, these gastric glands readily secrete large quantities of gastric fluid upon the food, just as the salivary glands pour out saliva in the mouth.[4] The gastric juice consists of water, containing some mild acids, and a peculiar substance called pepsin. It is by the action of the pepsin in the warm acid fluids of the stomach that the albuminoid foods are digested. The foods are all more finely divided and dissolved by the warm liquids and by the constant motion of the stomach.

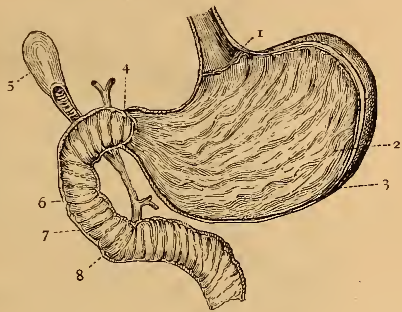


Fig. 27.

SECTION OF STOMACH.—1. Cardiac orifice. 2. Folds of mucous membrane. 3. Muscular wall. 4. Pylorus. 5. Gall-bladder. 6. Duodenum. 7. Folds of mucous membrane. 8. Entrance of bile and pancreatic juice.

As the albuminoids are prepared to enter the blood, they gradually pass directly through the mucous lining of the stomach into the blood-vessels. The gastric juices are in like manner re-absorbed into the blood. After being passed through the liver to the heart, the food finds its way to all parts of the body, so that hunger is soon gratified, and the strength of the body is increased. Such portions of the food as are not digested in the stomach pass, little by little, as a thin grayish mass, through the pylorus into the intestine. The stomach, after a season of active labor for two or three hours, is again empty, and takes its season of rest and repair.[5] Fig. 27 gives an internal view of the stomach.

58. Intestinal Digestion.—The small intestine is a long, crooked tube, hung in folds in the central portion of the abdomen.[6] It leads into the large intestine, or colon, which forms the last five feet in length of the alimentary

canal. In Fig. 28, we see the small intestine as it is folded into a great mass in the central part of the abdomen, with

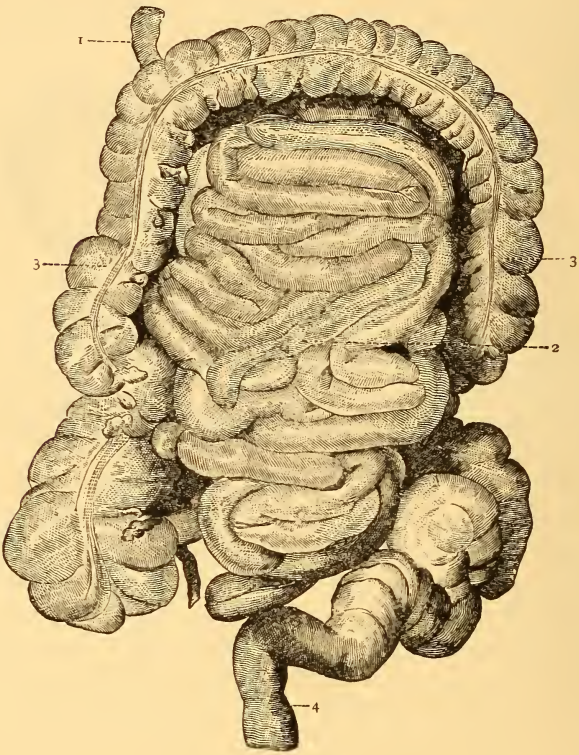


Fig. 28.

THE INTESTINES.—1. Beginning of Duodenum. 2. Small intestine. 3. Large intestine. 4. Rectum.

the large intestine placed around it. The coats of the intestines are the same in kind, number, and arrangement as those of the other parts of the alimentary canal, only they are much thinner. These coats have numerous glands in them which secrete the intestinal juices. The inner coat is not

only folded, as is that of the stomach, but it is densely set with minute villi, or hair-like rootlets. These villi dip into the food matter so as to afford every opportunity for the absorption of the nutrient particles, as the food is passed along by the worm-like motion of the muscular coat. See Fig. 29.

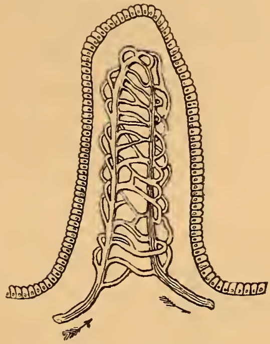


Fig. 29.

A Villus.—Ideal section, greatly enlarged, showing minute capillary circulation.

The first few inches of the small intestine, called the duodenum, serves somewhat as a second stomach. It is here that two peculiar fluids are received by a duct, one branch of which brings in the bile from the liver,[7] and the other the pancreatic juice from the pancreas.[8] These two fluids are different from the gastric juices, for they are alkaline (like lye) instead of acid, and they act specially upon the fats, starches, and sugars. By the action of these fluids, the food in the intestine becomes changed into a milky substance, called chyle, which readily enters the blood. The length of time required for the complete digestion of the food varies with the different kinds of matter, and with the conditions of the system; usually it is accomplished in from one to three hours.[9]

59. **Intestinal absorption** of food occurs in two ways: (1) As in the stomach, so here, the fluids return to the blood by passing directly through the inner coat of the intestine and the walls of the minute blood-vessels with which the mucous lining is densely filled. (2) Other portions are taken up by minute tubes, which have their beginning in the villi of the lining coat, and which draw the matter into themselves by the action of valves along their inner walls. These tubes are called lacteals, because the chyle that they draw from the intestines is milk-like in appearance. See Fig. 31.

60. The lacteals conduct the chyle from the intestines into numerous glands near by, called the mesenteries, from which a fewer number of lacteals lead the chyle into one large tube in front of the spinal column, called the thoracic duct. This duct conveys the chyle upward through the thorax, and pours it into a large vein under the left collar-bone. Fig. 30.

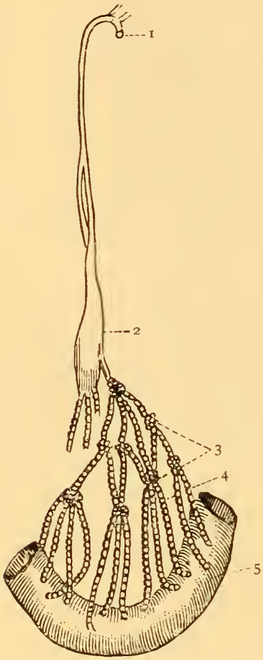


Fig. 30.

THORACIC DUCT AND LACTEALS.—1. Mouth of thoracic duct. 2. Lower end of duct. 3. Mesenteries. 4. Lacteals. 5. Intestine.

By these two methods of absorption, the food enters the blood and begins the process of nourishment. Such portions of the food as are not digested in the alimentary canal, pass into the colon and are finally cast out of the system.

61. Hygiene of Digestion.—The health and vigor of the system depend in the greatest degree upon the efficiency with which the body is nourished, hence the conditions that affect the process of digestion are very important. Among the more common points deserving attention are those set forth in the following article.

62. The manner of eating needs to be such (1) that the food shall be thoroughly chewed; (2) that the food shall not be taken with too much drink, since much water dilutes and weakens the digestive juices; (3) that very cold or very hot articles shall be avoided, since they change the temperature of the stomach; (4) that the food shall be eaten deliberately.

63. **The amount of food** needs to be sufficient to restore the waste of the system, and to satisfy the appetite, if it be a natural craving for food. Bread and fruit are much more easily digested than such substances as cheese, because they are not so concentrated. The amount of food required, as well as its kind, is much affected by exercise in the fresh air and sunshine. The active plow-boy needs more than the quiet school-fellow, and the former may readily digest such kinds of food as will prove quite indigestible to the latter. The quantity of food needed during crisp, freezing weather is much greater than that required in the lazy days of spring and summer.

Fig. 31.

END OF LACTEAL, showing wall and valves, greatly enlarged.

64. **The frequency of meals**, and the times of day at which they are eaten, need to be such that, after the organs have had opportunity to perform their work, they may have an equally long season for rest and repair. Three meals a day are sufficient for any healthy person, and a less number may be better for some. "Eating between meals" robs the organs of rest. Regularity in eating is one of the most important of requirements. Very late meals, or very heavy meals in the latter part of the day, often disturb the digestive organs. Light food in the evening will afford the best opportunity for sound and refreshing sleep during the night. Dreaming and restlessness are most frequently caused by excess of food, or indigestible matter, in the alimentary canal. It is improper to pass immediately from hard work of muscle or brain to the table, for the system needs time to prepare for the change. It is equally wrong to engage in active labor of any kind just after eating, for the forces of the system are required for a time in beginning digestion.

When one is tired or warm, let him rest before beginning to partake of food, and then eat deliberately.

The conditions of the mind affect both the appetite and digestion. Food eaten under peaceful and agreeable influences will receive the attention and energy of the digestive apparatus, while excitement, anger, sorrow, or discord will render the forces of the stomach almost powerless.

65. **Foreign substances** are frequently very injurious to the action of the digestive organs. The juice of tobacco, swallowed with the saliva arising from chewing or smoking the substance, inflames and weakens the nerves of the stomach. So does the alcohol contained in beer, wine, and whisky. Much alcohol arrests digestion. Strong condiments, such as salt, pepper, vinegar, mustard, etc., when taken in large quantities, irritate the delicate lining of the alimentary canal and impair digestion.[10]

Notes.

1. **Glands** are organs designed to take fluids from the blood. They change these fluids into juices, which they pour out for special purposes. This action of the glands is called secretion. Thus the perspiratory glands secrete perspiration, the lachrymal glands secrete tears, and the salivary glands secrete saliva.

2. **Starch and sugar** are of the same chemical composition. The digestion of starch consists in changing it into a form of sugar. This is done by the ptyaline of the saliva, and the acids and fermenting juices of the stomach and intestines. Starch will turn to sugar by being boiled with weak sulphuric acid. In all fermentation of starchy grains, the starch turns to sugar.

3. **Swallowing.** — How the food is caused to pass along the esophagus is illustrated by a horse as he drinks. Although his head may be low, he readily swallows the water upward into his stomach by contracting the muscles of the esophagus behind each swallow, and causing this contraction to run along the tube. The swallows may be seen to follow one another in wave-like form.

4. **Osmosis.**—Gases and liquids pass readily through moist membranes. If a bladder that is filled with brine be placed in a basin of fresh water, some of the brine will pass out through the walls of the bladder, and some fresh water will pass into the bladder. The watery part of the blood passes through the walls of the capillaries and glands. This passage of liquids through membranes is called osmosis.

5. **Digestion Observed.**—Through permanent openings accidentally made into the stomachs of human beings, and openings purposely made into the stomachs of domestic animals, the process of digestion has been fully observed, and many experiments have been performed to test the digestibility of various kinds of food.

6. **Objects for Examination.**—The viscera of the human body resembles very closely the corresponding parts of the common hog. The teacher and student may derive great profit from making close examination of the hog's intestines, stomach, heart, lungs, pancreas, liver, kidneys, and nervous matter.

7. **The liver** is a large, dark-colored gland, weighing three or four pounds, located on the right side just below the diaphragm. Its action is intimately connected both with digestion and circulation. It secretes from the blood about three pounds daily of dark, greenish, bitter fluid, called bile. While the intestines are resting, the bile is stored in a sack on one side of the liver, called the gall-bladder, to be poured into the small intestine at time of digestion. The bile seems designed in part to act on the fatty foods, and in part to carry off certain impurities from the blood through the intestines.

8. **The pancreas** is a long, flat gland, located just back of the stomach, weighing about one fourth of a pound. It is like the salivary glands in structure, and secretes a juice into the intestine to aid in the complete digestion of the foods.

9. **Digestibility of Food.**—The following is the length of time required for digesting various articles of food: raw apples, two hours; boiled beans, two hours and thirty minutes; roasted beef, three hours; wheaten bread, three hours and thirty minutes; milk, two hours; roasted pork, five hours; boiled rice, one hour; boiled potatoes, three hours and thirty minutes.

10. **Cleanliness of the Colon.**—The matter which passes into the colon requires to be cast out of the body regularly. If detained long in the colon, it irritates and inflames the organ, causes disagreeable gases, and produces painful constipation and indigestion. A regular daily habit is the only safe condition.

SUGGESTIVE QUESTIONS.

What definition of digestion may be given? What is the meaning of the word digest? Why does food require digestion? In what different ways is the food changed? What foods are chiefly digested in the stomach? What foods are acted upon by the intestines? What fluids are supplied in the different parts of the alimentary canal? What glands supply the different fluids? What importance attaches to proper mastication? How is food swallowed?

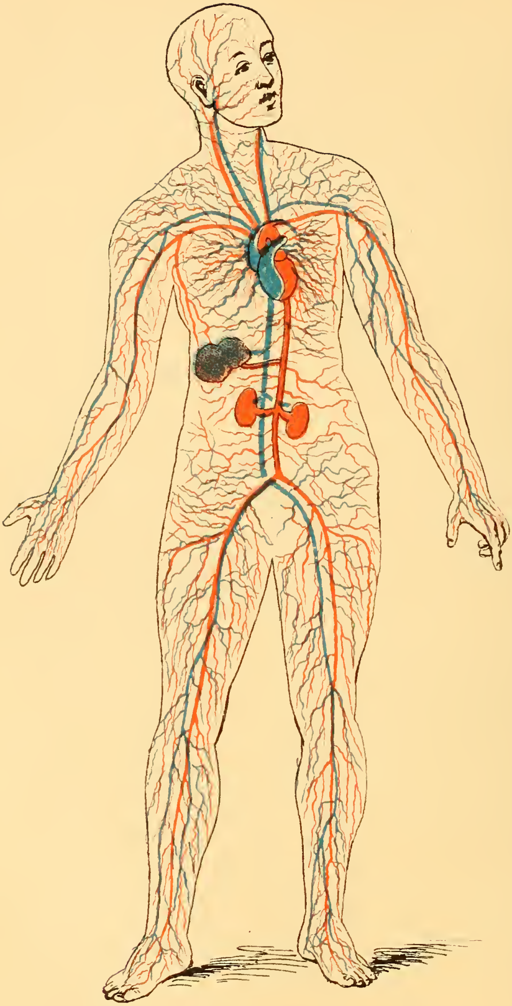
What is the purpose of each coat of the stomach? What causes the food to pass along the canal? What is absorption? How does absorption occur in the stomach? How does intestinal absorption take place? How does the matter which enters the lacteals reach the heart? What relation does proper digestion bear to health and vigor? What points are important in the manner of eating? How does exercise affect the quantity needed? How frequently should meals be eaten? At what times of day is it best to eat? How do strong articles like pepper and salt affect the alimentary canal?

TOPICAL OUTLINE.

Digestion.

1. Definition.
2. General Plan.
3. Alimentary Canal.
   - *a.* Mouth.
   - *b.* Pharynx.
   - *c.* Esophagus.
   - *d.* Stomach.
   - *e.* Small Intestines.
   - *f.* Large Intestines.
4. Changes Produced.
   - *a.* Mechanical.
   - *b.* Chemical.
5. Divisions of Process.
   - *a.* Mastication.
     - (1) Organs engaged.
     - (2) Changes produced.
     - (3) Importance.
   - *b.* Stomach Digestion.
     - (1) Structure of stomach.
     - (2) Changes produced.
     - (3) Absorption.
   - *c.* Intestinal Digestion.
     - (1) Structure of intestines.
     - (2) Changes produced.
     - (3) Absorption.
6. Hygiene.
   - *a.* Manner of eating.
   - *b.* Amount of food taken.
   - *c.* Frequency of meals.
   - *d.* Time at which meals are eaten.
   - *e.* Conditions of mind while eating.
   - *f.* Injurious foreign substances.

Plate III.



ORGANS OF CIRCULATION.

THE STROBRIDGE LITH. CO. CINCINNATI.

CHAPTER VIII.

CIRCULATION.

66. We now need to learn how the nourishment prepared by the alimentary canal is carried to every part of the body. This process is called circulation.

In every living thing there is a fluid that is constantly moving through the entire body. In plants this circulating fluid is the sap. In all higher animals, including man, it is a warm, red liquid, called blood.

67. The General Plan of Circulation.—The heart, like a tiny engine, forces the blood through long branching tubes that lead to every portion of the body. The blood then returns to the heart by running into other tubes, which empty into one another as do the streams of a river. These tubes finally empty the blood into the heart again in a continuous stream.

In the circulation through the body some very important changes occur in the blood: (1) In passing through the inner coats of the alimentary canal, it gains food; (2) in feeding the tissues, it loses its nutritious elements; (3) in passing over the worn-out particles in the body, the blood becomes impure by absorbing them; (4) at other places, the blood is purified by having the waste matter removed. By

these changes, the blood fulfills its great purposes as follows: (1) It nourishes the parts; (2) it purifies them; and (3) it warms them.

68. The blood is of a deep red color. It is somewhat thicker than water. It has a smooth quality, which causes it to flow very freely. It has a faint odor peculiar to the animal from which it is taken. It constitutes one twelfth the weight of the body. When the blood is examined by aid of the microscope, it is found to consist of two parts[1]: (1) Of vast numbers of minute bodies of circular form, called corpuscles (little bodies); and (2) of the fluid part, called the plasma. The plasma is the greater portion of the blood. The plasma carries the corpuscles and the food particles, as the water of a muddy stream floats the multitudes of fishes and the tiny particles of solid matter that are in it.

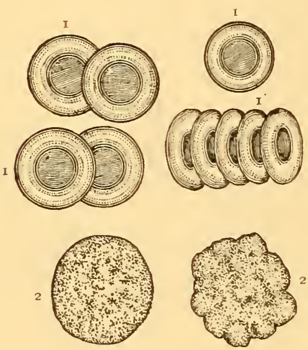


Fig. 32.

Corpuscles.—1. Colored. 2. Colorless.

69. The corpuscles are far too small to be seen without the aid of a microscope. The greater number of the corpuscles have a redish-yellow hue, and give color to the blood. Some of them are colorless. They are disc-like in shape, as shown in Fig. 32. The corpuscles appear to be of use in carrying the gases of the blood to and from the lungs.[2]

70. The plasma of the blood is a complex fluid. It is composed of two parts: (1) The greater portion is serum, which is chiefly water; and (2) it contains a small amount of fibrine in solution. This fibrine of the plasma is a peculiar substance, resembling the fibrine of lean meat and

the gluten of flour, so that some writers speak of this fibrine as "lean meat in solution."

71. **The fibrine** of the blood coagulates upon being exposed to the air; that is, it changes from its soluble or fluid form, to a stringy, tough mass, just as the albumen of egg hardens by being boiled.[3] By the coagulation of the fibrine, the blood is prevented from wasting when small

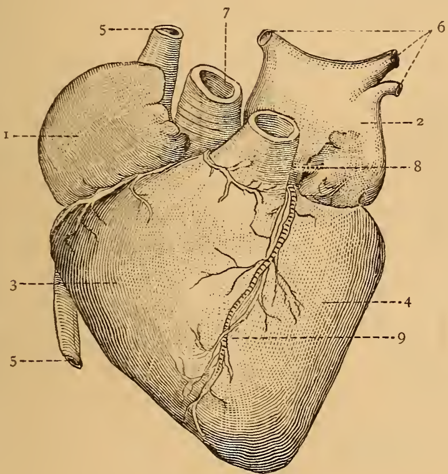


Fig. 33.

External View of the Heart.—1. Right Auricle, 2. Left Auricle. 3. Right Ventricle. 4. Left Ventricle. 5. Systemic Veins. 6. Pulmonary Veins. 7. Aorta. 8. Pulmonary Artery. 9. Coronary Vein and Artery,

blood-vessels are cut or broken. Coagulation is the great safe-guard against bleeding to death from hemorrhage from the nose or lungs, because it inclines to thicken the blood and to form a coating over the broken vessels so as to stop the flow of blood.

72. **The organs of circulation** are the heart, arteries, capillaries, and veins.

The heart is a double muscular organ, having four cavities, two on each side of an unbroken partition. This

partition divides the heart into a right and a left side. The two cavities on either side are known as auricle and ventricle. The auricles are the upper cavities, and the ventricles the lower. By this arrangement there are a right and left auricle, and a right and left ventricle. In Fig. 33, we have a front view of the heart, about one half the natural size.

73. **The passages of the heart** are of three sets, as follows: (1) There are openings into the auricles, so that the blood may flow into the heart; (2) openings at the bottom of the auricles, by which the blood passes down into the ventricles; and (3) openings out of the ventricles, through which the blood leaves the heart. The first openings are constantly open, so that the blood may flow in at all times; the second set are alternately opened and shut by door-like valves, which swing apart to let the blood pass down from the auricles into the ventricles, but which close again to prevent it from passing back; the third set are guarded by semicircular folds, which permit the blood to be forced out of the ventricles into the large tubes leading from the heart, but close promptly, to stop it from running back into the heart when the ventricles open to be filled again. By this arrangement, the blood enters the auricles of the heart in two constant streams, and is thrown out in two opposite streams from its ventricles. See Fig. 34.

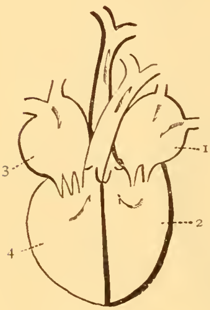


Fig. 34.

DIAGRAM OF THE PASSAGES OF THE HEART.—1. Left Auricle. 2. Left Ventricle. 3. Right Auricle. 4. Right Ventricle.

74. **The Action of the Heart.**—The two sides of the heart move together as one body in the following manner: The blood streams into both auricles until they are full, the right being filled by the returning blood from the system, and the left, by the pure blood from the lungs. The valves

which form the bottom of the auricles now open, and each ventricle is immediately filled by the blood from the auricle above it. The ventricles now contract with great power, by which movement the valves into the auricles are instantly closed, and the blood within the ventricles is forced with great violence into the passages leading away from the heart. The left ventricle forces its contents into the great tube, called the aorta, which leads to all parts of the body. The right ventricle forces its blood into a large tube, called the pulmonary artery, leading to the lungs. While the ventricles have been contracting, the auricles have again filled, so that, as the ventricles relax, they are again filled, and immediately repeat their former action. In this manner they alternately contract and relax, work and rest, during the whole of life. This action is called the beating of the heart. The frequency of the beating is tested by feeling the heart as it strikes against the chest, or by hearing the "beats," which are caused by the closing of the valves.[4] If the fingers are placed lightly on the "pulse," at the wrist, the beating may be counted. Under ordinary circumstances, the heart contracts about seventy-two times per minute.[5] The time occupied in contraction is less than two thirds of the whole interval of one beat, so that the muscles of the heart rest more than one third the time. Although the seasons of rest thus gained are extremely short, they amount to more than eight hours daily.

75. **The arteries** are the tubes that conduct the blood from the heart. They subdivide into a vast number of small branches, so as to convey the blood to every part of the system. The pulmonary artery receives the blood from the right ventricle, and distributes it to the lungs to be purified. The aorta receives the blood from the left ventricle and supplies it to the tissues of the body for their nourishment. The arteries are formed of very tough, elastic substance, and, when empty, resemble rubber tubes. The arteries have

a smooth lining, and are comparatively straight, so as not to lessen the force given to the blood by the heart. They are placed near the bones, and pass beneath the great muscles, in order that they may be shielded from danger. When they are cut or injured, there is great danger of bleeding to death. The blood in the arteries flows in jets, because of the beating of the heart. In Fig. 35, we see a portion of a large artery. In the lower part of the figure, the artery is represented as cut open, to show the absence of valves.

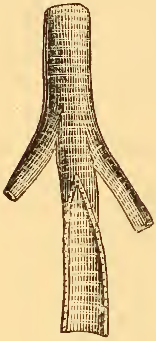


Fig. 35.

A Portion of an Artery.

76. **Capillaries.**—The minute, hair-like tubes, into which the arteries finally divide, are called capillaries. See Fig. 36. They are so extremely small that they are visible only by the aid of the microscope. They are about $\frac{1}{3000}$ of an inch in diameter. The skin, excepting the cuticle, is so full of these tiny vessels, that the point of a needle can not enter it without breaking some of them so that the blood flows out. The other membranes of the body are full of them in like manner. The walls of the capillaries are extremely thin—so very thin that the serum of the blood readily flows directly through these coats and bathes the various tissues in which the capillaries lie. It is in this way that the nourishment of the blood comes in contact with the portions that need it. The corpuscles do not pass through the coats of the capillaries, but are carried along within the capillaries.

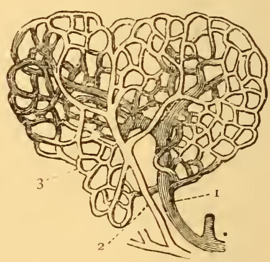


Fig. 36.

Capillaries.—1. Vein. 2. Artery, 3. Capillary.

77. **The veins** begin in the capillaries. By uniting into larger and larger tubes, the veins conduct the blood back to the heart. The pulmonary vein empties the pure blood from the lungs into the left auricle. The returning blood from the system is poured into the right auricle. The walls of the veins are thin and are chiefly formed of muscle. On the inner surface of the veins, there are many folds, which serve as valves, to permit the blood to flow only toward the heart. Fig. 37 represents a portion of a vein, laid open so that we may see the valves.

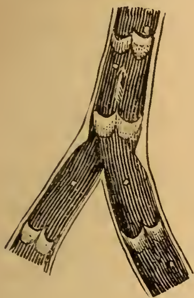


Fig. 37.
A Portion of Vein.

The veins are usually nearer the surface than the arteries are, excepting the large veins, which are located deep in the body. They are larger than the arteries, and more crooked. The blood flows through them in a gentle, regular current.

78. **The Circulation Traced.**—If a drop of blood be followed through the system, we may trace it, through the following ideal course: (1) It enters the heart at the opening into the right auricle, (2) passes through the tricuspid valve into the right ventricle, (3) is forced out through the semi-lunar valves into the pulmonary artery, (4) circulates through the capillaries of the lungs, and returns to the left auricle by way of the pulmonary vein, (5) passes through the mitral valve into the left

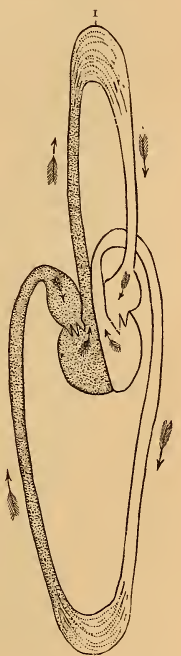


Fig. 38.
1. Capillaries of lungs.
2. Capillaries of system.

ventricle, (6) is forced out through the semi-lunar valves into the aorta, (7) circulates through the capillaries of the system, (8) and returns to the right auricle of the heart by way of the veins. In Fig. 38, the dark portion represents the venous blood. By following the course of the arrows, the pupil may readily trace the circulation from any point in the diagram back to the same point.

79. **The Pulmonary Circulation.**—The blood passes from the heart to the lungs, to be purified by the air that is breathed. By this means the blood loses its gaseous impurities and some water, and gains a fresh supply of new gases to be carried to the system. This is called the pulmonary circulation. Every drop of blood must pass through the lungs and return to the heart before it is sent out to nourish and purify the tissues.

80. **The Systemic Circulation.**—The pure blood is distributed to the entire body by the aorta and its branches, after which it returns to the heart. This is called the systemic circulation.[6]

81. **Assimilation.**—It is by the passage of the serum through the walls of the systemic capillaries that the food is brought to the growing cells of every tissue. How each kind of tissue takes from the blood the particular kind of matter needed for growth and repair, we do not know. It is true, however, that bone takes just such kinds of substance as are needed to make bone, and the muscles, cartilages, and nerves select what is necessary for them. We do not know how each tissue uses its proper nourishment for growth, and to repair the waste portions of the body. This intricate and unknowable process of nourishment is called assimilation. Assimilation is evidently the crowning purpose of both digestion and circulation. Assimilation takes place most rapidly during rest, especially during the unbroken quiet of sound sleep.

82. **Removal of Waste Matter.**—Not only does the

blood nourish the tissues, as just stated, but it is as much the purpose of the blood to remove the waste matter. The blood changes the worn-out particles to a soluble form, and absorbs them into itself as it flows through the tissues. The impurities are finally removed from the blood.

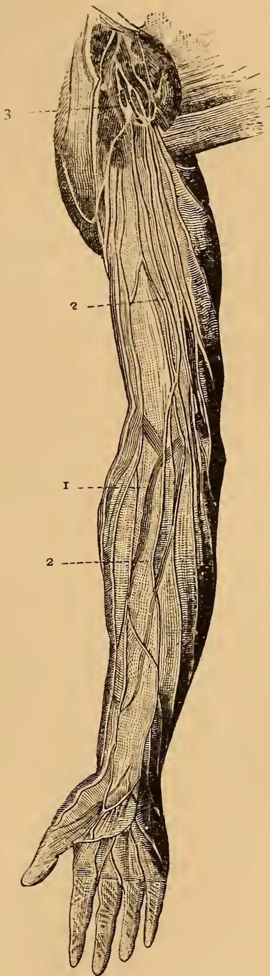


Fig. 39.

Superficial Lymphatics of the Right Arm.—1. Vein. 2. Lymphatic tubes. 3. Lymphatic glands.

83. The Lymphatics. — The fluid that passes out of the systemic capillaries into the surrounding parts, returns to the veins by two methods of absorption: (1) much of it returns by being re-absorbed through the walls of the capillaries and minute veins; (2) there are special tubes for absorbing this fluid, called lymphatics. The lymphatics have their outer ends in almost all parts of the system, and by leading toward the heart they unite, and finally pour their contents into the large veins. See Fig. 39. These tubes are of extreme delicacy of structure, so that absorption readily takes place through their coats. They have valves in them which permit their contents to flow only toward the heart. Fig. 31 represents the end of a lymphatic, as it does the end of a

lacteal. In time of hunger and starvation, the lymphatics suck up the fatty portions, and enable the individual to live for a long time on his own flesh and fat.[7] The lymphatics that have their origin in the lining coat of the alimentary canal, are called lacteals.

84. **Hygiene of Circulation.**—The body is designed to be active. Proper exercise of its parts is favorable to proper circulation of the blood. Especially does exercise of the voluntary muscles promote increased circulation. The muscles, in contracting, press on the veins and force the blood toward the heart, while the relaxation of the muscles permits the veins to fill again from the capillaries. Exercise causes the heart to beat faster, and the whole circulation to be quickened.

Exercise increases the demand for nourishment. More food is needed, the appetite is sharpened, and the digestion is improved. The more thorough the flow of blood through the tissues, the more perfectly is the waste matter removed from the body. Hence, proper exercise promotes assimilation, and facilitates the prompt removal of waste material. These two processes, when fully performed, are the very essence of health and vigor.

Exposure to the sunlight and fresh air also enlivens the flow of blood, and improves the quality of the blood. Close-fitting garments, and tight bands about the waist, neck, and extremities, tend to stop the proper flow of the blood. They should be carefully avoided. Tight garters, or shoes laced closely about the ankles, make the feet cold by arresting the flow of blood.

The circulation is often seriously interrupted by sudden changes to cold temperature, or by exposure of some part of the body to draft of air. The circulation may be injured by getting the clothing wet, or by suddenly cooling after exercise. Such changes in the circulation tend to cause "chill" and to produce inflammation, resulting in "cold."

When, by accident, blood vessels are cut, the flow of blood may be stopped by pressure upon the wound. If an artery is cut, the blood will flow in jets, and will be of a bright red color. In such a case, pressure needs to be made by a tight band between the wound and the heart. If veins only are cut, the blood will flow regularly, and will be dark red, in which case pressure needs to be made beyond the cut.

Fainting is caused by want of blood in the brain. In case a person should faint, place him in a horizontal position, with his head low. More blood will then flow to the brain, and the fainting will be relieved.[8]

Notes.

1. **The Composition of the Blood.** — The following outline shows the composition of the blood:

Blood.	Corpuscles . .	Colored.	Clot of Coagulated Blood.
		Colorless. . . .	
	Plasma.	Fibrine.	
		Albumen.	
		Serum	Water.
			Salts.
			Soluble Food.

2. **The blood corpuscles** are of the form of discs, or flattened drops. They are about $\frac{1}{3500}$ of an inch in diameter across the disc, and one fourth as much in thickness, being thinnest in the middle. The colorless corpuscles are fewest in number, being one to every three hundred of the colored corpuscles. The colorless are larger than the colored. To see the corpuscles, place a drop of freshly drawn blood on a clean microscopic slide; lay on a piece of thin glass, to spread the drop, and put the slide under a powerful objective. The corpuscles may be seen moving about in the plasma.

3. **Coagulation.**—When blood is exposed to the air, it separates into two parts—the clot and the serum. This separation is caused by the coagulation of the fibrine. As the fibrine becomes solid, its fibers entangle the corpuscles, and strain them out of the serum, leaving the latter quite clear. The corpuscles and the fibrine form the clot.

4. **The Sounds of the Heart.**—By putting the ear close to the chest of another, we may hear the beating of the heart. There are two kinds of sounds: (1) A sound longer in duration, and lower in pitch, heard over the ventricles; (2) a shorter, sharper sound, heard most plainly over the base of the heart. It is thought that the first sounds are caused by the sudden closing of the valves between the ventricles and auricles; and the second, by the closing of the semi-lunar valves at the entrance to the large arteries. Expert physicians can determine much about the diseased condition of the heart by the character of the sounds.

5. **Rapidity of Heart-beat.**—The causes that produce more rapid beating are exercise, warmth, rich food, stimulating drinks, and excitement. In fever the heart beats rapidly. As a person grows feeble from any cause, the beating usually grows more rapid, but less powerful. When awake, the pulse is considerably faster than while asleep, and, in standing, it is more rapid than while lying quietly.

6. **Portal Circulation.**—The blood that returns from the alimentary canal passes through the liver before reaching the heart. This is called the portal circulation. The veins from the stomach and intestines lead into one large vein (the portal vein) that enters the liver. This vein divides, to form the capillaries of the liver. Having passed through the liver, the blood flows into the large vein that empties in the heart. The changes that occur in the blood as it passes through the liver are not fully known. The

bile is secreted from the blood, and the amount of sugar in the blood is increased by the circulation through the liver.

7. **Absorption.**—In recent years, there have occurred many cases of remarkable "fasting," in which persons have lived without solid food for forty days or more. Such persons drank water to maintain the fluidity of the blood, while they lost in weight at the rate of a pound (more or less) per day by the absorption of their fat and other tissues. Such persons ate themselves during the time of their fasting.

8. **Headache.**—If too much blood flows to the brain, dizziness and headache may result therefrom. If headache results from such a cause, moderate exercise of the muscles will tend to relieve it, by causing less blood to flow to the brain. If headache results from impurity of the blood, exercise will in like manner tend to relieve it.

Suggestive Questions.

What are the great purposes of the circulation of the blood? What is the blood of a tree? What is the composition of the blood? What is the use of the corpuscles? How is the blood itself nourished? Which part of the blood carries all the other parts? Why are the large arteries seldom cut? Why may we compare the heart to an engine? What is a heart-beat? What causes the blood to return to the heart? Why is the left ventricle strongest?

Of what is the heart made? How is the heart nourished? How may we cause the heart to beat more rapidly? What are capillaries? What changes occur to the blood in passing through the coats of the alimentary canal? What changes occur to the blood in the tissues? How may exercise relieve headache? What are lymphatics? What are the effects of exercise upon the blood? Why does brisk exercise in the open air cause hunger? Why do we need extra clothing while asleep? Why does starvation or sickness cause one to become thin? Why should we not remove coat or shawl just after exercise, in order to "cool off?" How are the circulatory organs injured by tight lacing? Why will a hot foot-bath tend to relieve headache? Why do students suffer with cold feet?

Topical Outline.

Circulation.

1. Definition.
2. General Plan.
3. Purposes.
   a. To Nourish.
   b. To Purify.
   c. To Warm.
4. The Blood.
   a. General Character.
      (1) Appearance.
      (2) Amount.
   b. Composition.
      (1) Corpuscles.
         (*a*) Colored.
         (*b*) Colorless.
      (2) Plasma.
         (*a*) Serum.
         (*b*) Fibrine.
3. Organs.
   a. Heart.
      (1) Structure.
         (*a*) Cavities.
         (*b*) Passages.
      (2) Action.
   b. Arteries.
   c. Capillaries.
   d. Veins.
6. Complete Circulation.
7. Pulmonic "
8. Systemic "
9. Assimilation.
10. Removal of Waste Matter.
11. Lymphatics.
12. Hygiene.
   a. Effects of Exercise.
   b. Effects of Air and Sunlight.
   c. Effects of Chill.
   d. Accidents.
   e. Fainting.

CHAPTER IX.

RESPIRATION.

85. Demand for Air.—It has been shown that the body constantly requires to be nourished by food, and that this food must be circulated to all of the parts by the blood. But the body can not live by these processes alone, however rich the food, or perfect its digestion and circulation.

All living things require the action of another very important element. They demand the presence of the air, and require that some portion of it shall constantly enter their blood, as food does, and be circulated to their parts. Just as all living things must have food to eat, and water to drink, so must they have air to breathe. No other want is more urgent than this demand for air. Men may live for weeks without solid food, and may live for several days without water, but the absence of air, for even a few minutes, causes death.

The plants spread their leaves in the air and sunlight, and take what they need from the atmosphere through the great surfaces thus exposed. Fishes obtain air, by means of their gills, from the water in which they swim. The higher animals that live in the air, take it into their blood through very thin membranes, arranged in the chest, called lungs. The process by which the air passes in and out of the blood is called respiration.

86. What the Air Does.—The part of the air that is thus taken does not form new tissues, as bread and meat do, hence, in this sense, air is not food. The air thus taken performs other important uses, as follows: (1) It aids in preparing the food for assimilation; (2) it acts upon the food in the blood to cause the warmth and vigor of the body; (3) it changes the worn-out particles of the tissues, so that they may be absorbed by the blood and be swept out of the system. More briefly stated, the purposes of respiration are: (1) *to warm*, and (2) *to purify* the body.

87. The General Plan of Respiration.—The chest, in which the lungs are placed, is open to the external air by a set of passages connecting with the nose; by the action of certain muscles, the chest is enlarged, so that the air rushes in, and, after a short interval, is made smaller again, so that the air is forced out. By repeating these changes in the size of the chest, the air alternately passes in and out of the lungs.

The air in the lungs is separated from the blood by a very thin, moist membrane. The air readily passes through this thin membrane into the corpuscles of the blood. The air is then whirled away by the blood to every portion of the body.

88. The air surrounds the body, at all times, in the form of an invisible, odorless, tasteless gas. It forms a vast ocean of fluid, enveloping the earth to the depth of many miles. It is best known to the senses when it moves in a strong wind. It is the air that sways the tops of trees, supports the birds in their flight, and that bears up the clouds.

The air is a mixture of several gases. The four principal parts of the air are oxygen, nitrogen, carbonic acid, and watery vapor.

89. Oxygen forms about one fifth of pure air. It is the oxygen that unites with substances to burn them. It

is the oxygen that enters the corpuscles and causes the warmth of the body.

90. **Nitrogen** forms about four fifths of the air. Nitrogen does not unite with things to burn them, nor does it support life. Its great service to man is that it dilutes the oxygen, which would be too rich and active if the air were composed of it alone. Nitrogen is not poisonous.

91. **Carbonic acid gas** forms a very small part of pure air. Carbonic acid gas is produced by all kinds of combustion, by the decay of organic matter, and by the breathing of animals. It aids in supporting the growth of plants. It is not poisonous, but destroys animal life by causing suffocation.[1]

92. **Watery vapor,** which is water in the form of gas, is a very small part of the air. It is constantly evaporating from bodies of water, and from the moist earth. It is also produced by the breathing of animals.

93. **The organs of respiration** are the air passages, the lungs, and certain muscles that cause the breathing.

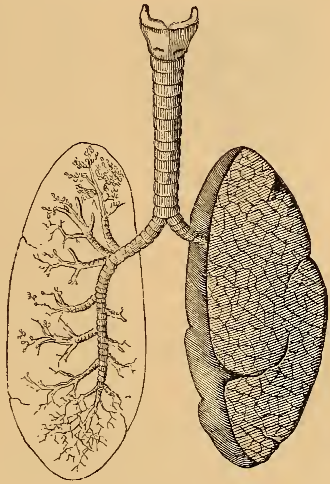


Fig. 40.

IDEAL DIAGRAM OF LUNGS AND AIR-PASSAGES.

94. **The air-passages** are: (1) The nasal openings, which lead back to the pharynx; (2) the larynx, a short, cartilaginous box, in which the voice is produced; (3) the the trachea, or wind-pipe, leading from the larynx to the central part of the chest; (4) the branches formed from the trachea, called bronchial tubes. The bronchial tubes subdivide until, finally, they

Pgy.—6.

end in clusters of tiny sacks, called air-cells, which form the inner and closed ends of the air-passages. In Fig. 40, we see a diagram of the lungs and air-passages, with the larynx at the top of the figure, the trachea leading downward and dividing into many branches. The dark portion of the figure, to the right, represents the left lung entire. On the opposite side, the substance of the right lung is removed to show the manner in which the bronchial tubes subdivide.

95. The Trachea and Bronchial Tubes.—The trachea is a membranous tube, some four or five inches long, and less than an inch in diameter. It is formed mainly of cartilaginous C-shaped rings, placed one above another, with the open part behind. These rings keep the trachea open. The bronchial tubes are similar to the trachea in structure, but they are smaller and have thinner walls. The air-cells have extremely thin membranous walls, which separate the air within them from the blood in the capillaries of the lungs. There are many millions of cells, so that their entire surface for the absorption of the air is very great. Fig. 41 shows how the bronchial tubes end in clusters of air-cells. The lining of the air-passages is very sensitive, especially in the larynx and trachea, so that any foreign body that may be drawn into them causes pain and violent coughing until it is expelled. The lining of the bronchial tubes is covered with a peculiar hair-like kind of cells, called cilia, which aid in removing dust from the lungs.

Fig. 41.

CLUSTER OF AIR-CELLS. — 1. End of Bronchial Tube. 2. Air Cell.

96. The lungs are two large, soft lobes that fill the chest. The lungs are formed of the bronchial tubes and air-cells, and of the blood-vessels of the pulmonic circula-

tion. Soft, fibrous tissue fills between these various tubes, to support and bind the whole together. These two great sets of passages, the one for the air, the other for the blood, are arranged as closely together as possible, so as to expose the blood to the action of the air. The outside of the lungs is covered with a delicate membrane, called the pleura. This smooth membrane also lines the inner surface of the chest. In all movements of the lungs these two smooth membranes rub together, so that all friction is avoided.

97. The movements of the chest, that cause the air to flow in and out of the lungs, are produced by the action of the diaphragm and intercostal muscles. The diaphragm is a thin, broad, circular partition across the body, separating the abdomen from the chest. It forms the bottom of the chest, and is arched upward, like an inverted saucer, fitting closely under the lungs. Its outer edge is fastened to the walls of the body, with the muscular fibers extending inward toward the center. When these fibers are contracted, the diaphragm is pulled down and made more nearly level. This causes the cavity of the chest to be made larger. At the same time, the intercostal muscles, whose fibers fill the spaces between the ribs, contract and lift the ribs upward and outward, causing the chest to become broader. By these two actions, the chest is made larger in all directions. This enlargement causes the air to flow into the lungs, and the action is called inspiration. The fully expanded chest is represented in the ideal section, Fig. 42.

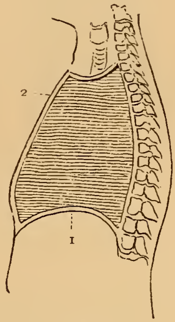


Fig. 42.

INSPIRATION.—1. Diaphragm. 2. Sternum.

When these muscles relax, the elasticity of the parts that have been pulled out of the shape, causes them to return to their original form and position, so that the chest becomes

smaller. This action forces a part of the air out again, and is called expiration. In Fig. 43 we see the chest represented at the close of an expiration.

The lungs at all times fill the chest, and at all times contain air. Their capacity at time of full inspiration is about one gallon, and at time of expiration twenty to thirty cubic inches less. With each breath, about a pint of new air enters the lungs, to mix with what is already there, so that, in exhaling, some of the old air passes out.[2] The air of the lungs is constantly mixing and changing with that which is being breathed, so that air in the lungs is entirely renewed in a short time. By this arrangement, the air that is next to the blood is not suddenly changed, and the fresh, cold air does not come in contact with the surfaces of the air-cells.

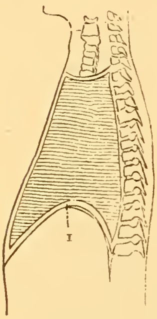


Fig. 43.

EXPIRATION.—1. Diaphragm.

The frequency of respiration depends upon the rapidity of the circulation of the blood. Usually, there are from seventeen to twenty inspirations to the minute. If the circulation is increased, the breathing is usually more rapid.

98. Changes in the Air and Blood.—While the air is in the lungs, a large portion of the oxygen of the air enters the blood, so that, after being in the lungs, the air will not support combustion, nor is it fit to be again breathed. While the air is in the lungs, it receives three substances from the blood, namely: (1) Carbonic acid gas, (2) watery vapor, (3) organic matter. The presence of these substances in the exhaled breath may be shown as follows: by breathing into a glass containing some lime-water, a milky sediment will be formed in the water by the carbonic acid contained in the breath; by breathing on a cold pane of glass the vapor of water of the breath will be condensed into a film of water

on the glass; by breathing into a bottle, and keeping such breath confined for a short time, a bad odor is developed in the vessel by the organic matter of the breath.[3]

The changes that occur in the blood by respiration are quite evident from the changes produced in the air. The blood that passes to the lungs through the pulmonary artery is the dark, impure, venous blood that has just returned to the heart from the system. In passing near the air-cells in the lungs, the blood receives the oxygen of the air, and gives off some of its carbonic acid, water, and organic impurities. The color of the blood is changed from a dark, bluish hue to a bright scarlet color. It returns to the heart greatly purified.

99. **The Function of the Air in the Blood.**—It is mainly the oxygen of the atmosphere that enters the blood corpuscles in their passage through the lungs. This oxygen is distributed throughout the system, and unites with the carbonaceous food, and other substances, in the capillaries and tissues. By this union, a slow combustion occurs, by which heat is liberated to the surrounding parts, much as heat is caused by an ordinary fire. The products of this combustion are carbonic acid gas, water, and various salts, all of which are left in the blood as impurities.

The oxygen also consumes the waste tissues of the body, thereby causing more heat, and producing more impurities in the blood. It is in this way that oxygen serves as the direct agent in warming and cleaning the body.

Mr. Huxley speaks of oxygen as "the sweeper of the living body."

100. **Hygiene of Respiration.**—Since respiration affects immediately the purity of the blood, it is evident that the health of the body must be greatly influenced by the kind of air breathed, and by the fullness of respiration.

101. **Ventilation.**—The outdoor air is pure. It contains the proper amount of oxygen, and the other com-

ponents are so completely diffused that they are not injurious. The air of dwellings is generally deficent in the amount of oxygen, and contains various impurities. This difference exists, (1) because the air of houses is not sufficiently free to circulate with the outdoor atmosphere, and (2) because it receives the gases thrown off as impurities from the bodies of those who live within, together with the impurities arising from heating, lighting, cooking, etc. Especially does the air of sitting-rooms and sleeping apartments, of school-rooms and factories, of churches and public halls, contain an excess of carbonic acid gas and organic matter, while the oxygen is speedily reduced below the proper amount. The process by which the foul air of rooms is replaced by fresh air is called ventilation.

The organic impurities thrown off from the lungs and skin are of the most noxious character. Air containing such impurities is wholly unfit to be breathed again. Especially is this true of the air thrown off from persons afflicted with disease. For this reason, both for the sake of the individual who is sick, as well as for the safety of the attendants, rooms containing diseased persons should be most carefully ventilated. Sleeping-rooms need to have the sunlight and fresh air freely admitted during the day, and at night they should have sufficient openings at windows and transoms to permit change of air. An open fire will ventilate a sitting-room, while if closed stoves and heaters are used, there must be other ventilating openings beside those of the cracks of doors and windows. It is better to consume more fuel than to shut off the avenues of pure air for the sake of keeping warm. Just as the air is continually rendered impure, so should there be adequate means for its constant removal and renewal. The morbid effects of impure air frequently produce restlessness, irritability, dullness, headache, and loss of appetite. Long continued exposure to impure air results in painful and fatal diseases.[4]

Since the air within is warm, openings made near the top of the room will both permit the impure air to escape, and the fresh air to enter. Small openings that can remain open, at the top and bottom of the room, on opposite sides, may produce constant change of air without causing an injurious draught. In any case there must be sufficient openings for the air to pass in and out.[5]

102. **Manner of Breathing.** — Beside the precaution concerning the purity of air, much attention needs to be given to the manner of breathing. The amount of air taken is quite as important as its purity. The chest requires free movement, that sufficient air may enter the lungs. The lower portion of the chest is naturally largest and most yielding as a means of full and deep respiration. Many persons, however, lace this part of the chest so tightly as to wholly deform it, making the lower portion more slender than the portion above, and robbing the chest of all freedom of motion. By this deformity, the liver and stomach are crowded downward into the lower part of the abdomen, and the lungs are greatly diminished in volume and breathing capacity. Upon no other part could continued pressure be made that would be so fatal to the health.

The lungs are quite as often and as seriously injured by habitually sitting or standing in such position that the chest is cramped and the breathing is limited and feeble. Stooped shoulders and hollowed chest are deformities that are extremely ungainly in appearance, and that tend to cause weak lungs. By persistent attention, a person may acquire the habit of holding the shoulders back, and, by full breathing, may permanently increase the capacity of the lungs to a very great extent. The erect position and full chest are typical of health and strength. There are three features of correct breathing that no one can afford to neglect: (1) Breathe pure air; (2) give the chest free motion; (3) maintain erect form and full inspiration.

In breathing, the proper opening for the passage of the air is the nose. The mouth is not an air-passage. It is quite injurious to the throat and lungs to breathe through the mouth. One should be careful to sleep with the mouth closed.

103. The Voice. — The voice is produced by the vibration of the vocal cords. These cords are located in the larynx. The larynx is situated at the upper end of the neck, and forms the air-passage from the pharynx to the trachea. The large prominence that may be seen or felt just below the lower jaw, on the front part of the neck, is the larynx. See Fig. 44. The larynx is a cartilaginous box, about two inches long, and more than an inch in breadth. Its walls are formed of four plates of cartilage, that so fit upon one another that we may readily change the shape and size of the larynx.

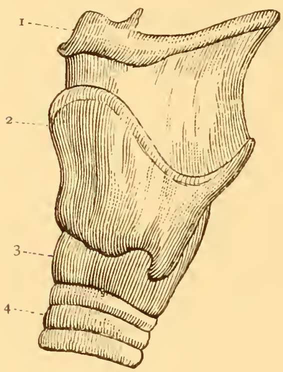


Fig. 44.

External View of the Left Side of Larynx.—1. Front portion of hyoid bone. 2. Upper edge of larynx. 3. Lower portion of larynx. 4. Second ring of trachea.

The interior of the larynx is lined with mucous membrane. This membrane is very sensitive, so that violent coughing is caused if anything touches it. The larynx is closed at the top by the epiglottis, a long piece of cartilage that is attached to the base of the tongue. The epiglottis closes over the larynx while we swallow, and at other times is raised, so that the larynx is open for the passage of the air to and from the lungs.

104. The Vocal Cords.—The vocal cords, by which the sound is made, are within the larynx. They are not strings, but are simply folds of the mucous membrane that

lines the larynx. These folds are on the sides of the larynx. There are four folds, or cords, two above, one on each side, called the false cords, and two below, one on each side, called the true cords. Their edges are smooth, and are quite sharp. When sound is being made by them, they nearly meet across the larynx.

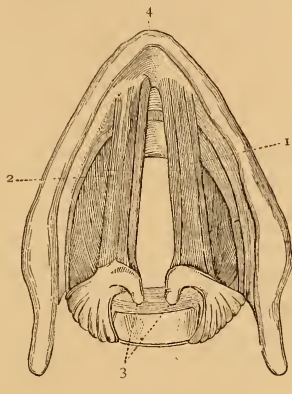


Fig. 45.

Cross Section of the Larynx above the Vocal Cords.—1. Right vocal cord. 2. Left vocal cord. 3. Cartilages to which the vocal cords are attached behind. 4. Front edge of the larynx.

105. How the Voice is Made.—During ordinary breathing, no sound of the voice is made; in such cases, the cords are not stretched tightly across the opening of the larynx, but are relaxed, and the air passes through the larynx without obstruction. In order to make a sound, we draw the cords tightly, and, by stretching them, make them draw close together, so as to nearly close the passage of air through the larynx. Their edges almost touch, and are thin and tight. While in this condition, we force the air between them, and thus cause the edges of the cords to vibrate very rapidly. The vibrations of the cords and of the air surrounding them produce sound. We change the sound by the way in which we stretch the cords, and by the size and shape we give to the larynx and mouth. If the cords are drawn very tight, they vibrate more rapidly, producing an acute sound; if they are more loose, and are thicker, they produce a sound that is more grave.

The loudness of the voice depends upon the force with which the cords are caused to vibrate. This depends almost wholly on the power with which the breath is forced out of the lungs. To have a full, round, strong voice, one needs

to have a full, strong chest and diaphragm, and to speak with plenty of air in the lungs.

The articulation of sounds, by which we are enabled to speak, is performed by the lips, tongue, and teeth. The quality of the voice, or that peculiar property of it by which we recognize the voice of any person, depends upon the shape of the chest, trachea, larynx, and nasal cavities.

The power or force of the voice may be very greatly developed by proper exercise and training of the vocal organs. Any one who will give the lungs their natural freedom, and will breathe deeply and fully, may speak in a loud tone. The weak voice is usually indicative of inefficient breathing. The purity of the tone and clearness of articulation may be greatly improved by intelligent practice. By practicing upon the elementary sounds of words, the most difficult combinations of sounds may be mastered. Singing and reading aloud are most excellent exercises for developing the voice. The lungs, too, will gain in power. One who sings or speaks much will not be likely to suffer from weak lungs.

Notes.

1. **Carbonic Acid.**—The amount of carbonic acid in the atmosphere of different regions has been estimated about as follows:

Open air of country.............	.4	in 1000 parts of air.
" " " city	.5	" " " " "
In school-room, ventilated.......	2.	" " " " "
In school-room, not ventilated...	30.	" " " " "
In bed-room, before airing......	5.	" " " " "
In bed-room, after airing	1.	" " " " "
In exhaled air	40.	" " " " "
In air causing distress..........	5.	" " " " "

2. **Volume of Lungs.**—The following estimates have been made of the capacity of the lungs:

Residual air that can not be exhaled	100	cubic	inches.
Reserve air that is not ordinarily exhaled	100	"	"
Tidal air of ordinary respiration	25	"	"
Complemental air possible after ordinary inspiration	115	"	"
Ordinary capacity nearly	230	"	"
Extreme capacity nearly	340	"	"

The left lobe of the lungs is somewhat smaller than the right, as the heart lies somewhat more in the left side of the chest than in the right.

3. The following table shows the principal changes produced in the blood by its passage through the lungs.

	Venous.	*Arterial.*
Oxygen	8 per cent	18 per cent.
Carbonic Acid	15 to 20 per cent	5 per cent.
Color	Dark blue	Scarlet.
Water	More	Less.

4. **Diseases of the Lungs.**—The most common and fatal disease of the lungs is pulmonary consumption. This disease consists in actual disorganization of the substance that composes the lungs. It must lead finally to fatal results. Consumption occurs most frequently from heredity, in which children suffer weakness as a result of the diseased conditions of their parents. In such casess, it is almost impossible to avoid the fatal tendencies. Consumption may have its origin in injuries resulting from frequent heavy "cold;" or it may result from continu d impurity of the blood. The most robust person, if exposed to foul air for a long time, will finally yield to fatal tendencies to consumption. On the other hand, persons who have inherited the disease are comparatively safe from its ravages if they live sufficiently in the free air and sunlight, in regions in which the air is dry, and the changes in temperature are not great.

Organic impurities thrown off from the lungs float in the air as noxious germs. Especially is this true of the matter that passes off from diseased persons. It is by breathing such matter that diseases are often contracted. The breath from one afflicted with consumption, scrofula, diphtheria, typhoid fever, or any other disease of such decided character, is wholly unfit to be rebreathed by any one.

5. **Ventilation** depends on the movement of air in currents, caused by differences in temperature. Warm air, being lighter, rises, while

cold air, being heavier, descends. Special contrivances for ventilation must admit fresh air and conduct away the foul air. This is usually accomplished by registers for admitting pure air near the upper part of the room, while the impure air is led away by conducting shafts from the lower part of the room. The passages for the exit of foul air should lead into warm flues or chimneys, so that there may be a sufficient upward current. The fresh air that is admitted need not be cold, but may be warmed before it enters. This may be done by passing it over heating surfaces. The air arising from cellars or sewers should in no case be allowed to enter the rooms of dwellings. Cellars should have openings for the escape of their air.

Suggestive Questions.

What are the purposes of respiration? How does the need of air compare with the want of food? How do plants breathe? Why do all living bodies need air? What is the composition of the air? Why are carbonic acid and water found in the exhaled breath? How may we show the presence of carbonic acid in the exhaled breath? How may we show water to be in the breath? Why may we see the breath in frosty weather? How is the body warmed? What different structures compose the lungs? Why do we call the oxygen the "sweeper of the living body?"

What changes are produced in the air by respiration? How does breathing alter the blood? How do we cause respiration? Why should we not make the beds early in the day? What benefits come from an open fire? How may the power of the lungs be impaired? How may the power of the lungs be increased? Why should we wear shoulder-straps to support the weight of the clothing? What part of the body needs the loosest clothing? How may we best ventilate a school-room? What evils result from stooped shoulders? Why are soldiers required to maintain the erect form and full chest? What conditions favor the development of consumption?

How is the sound of the voice produced? What are the vocal cords? How do we make different kinds of sounds? What do the lips, tongue, and teeth have to do with the voice? How may we speak in a loud tone? How may we strengthen the voice?

Topical Outline.

Respiration.

1. Definition.
2. Universality of.
3. Purposes.
   a. To warm.
   b. To purify.
4. General Plan.
5. Air.
   a. General character.
   b. Composition.
      (1) Oxygen.
      (2) Nitrogen.
      (3) Carbonic acid.
      (4) Watery vapor.
6. Organs of.
   a. Passages.
      (1) Nasal openings.
      (2) Pharynx.
      (3) Larynx.
      (4) Trachea.
      (5) Bronchial tubes.
      (6) Air cells.
   b. Lungs.
      (1) Air tubes.
      (2) Blood tubes.
      (3) Connecting tissue.
      (4) Pleura.
   c. Muscles.
      (1) Diaphragm.
      (2) Intercostal.
7. Process.
   a. Movements.
      (1) Inspiration.
      (2) Expiration.
   b. Changes.
      (1) In air.
      (2) In blood.
8. Hygiene.
   a. Ventilation.
   b. Manner of breathing.
9. Voice.
   a. Organs of.
      (1) Larynx.
      (2) Vocal cords.
      (3) Mouth.
      (4) Nasal cavity.
   b. How produced.
   c. How modified.
   d. How cultivated.

CHAPTER X.

EXCRETION.

106. The process by which the system is constantly cleaned, is known as excretion. Nutrition renews and builds up, excretion clears away and purifies. These two acts, taken together, form the one great process of life in the body.

107. **The Impurities.**—The matter to be excreted is chiefly produced by the oxidation of food and waste tissue. This impure matter is formed in all parts of the system. The impurities are mainly carbonic acid gas, water, and various other substances, the most abundant of which is urea. These substances are all soluble in the blood, and are absorbed by it as it flows through the body. The blood, as it flows into the veins, washes these impurities from the various tissues into the veins. It is for this reason that the venous blood is impure, and it is in this way that the blood serves to clean the body.

108. **Organs of Excretion.**—There are certain organs designed to remove the impurities from the blood. These are the lungs, skin, and kidneys.

The structure of all of these organs is such that the blood, as it flows through them, is spread out over a vast

surface of capillaries. The walls of these capillaries are very thin, and separate the impure blood on the one side from open tubes and passages on the other side. These open tubes lead out to the air. Through this delicate partition the impurities pass from the blood, and are then cast out of the body. This arrangement has been explained in the structure of the air cells of the lungs and the perspiratory tubes of the skin.

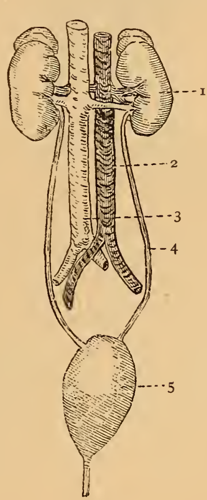


Fig. 46.

KIDNEYS AND THEIR VESSELS.—1. Left kidney. 2. Ascending vein. 3. Aorta. 4. Left ureter. 5. Bladder.

109. **The kidneys** seem specially designed to purify the blood. They perform no other purpose. The kidneys are two in number, located in the back portion of the abdomen, one on each side of the spinal column, a short distance below the diaphragm. See Fig. 46. They are dark-colored, bean-shaped bodies, about two thirds as large as the closed fist. They are like the lungs, in being made of two kinds of vessels: (1) Blood-vessels, (2) exit tubes. Large branches of the aorta, called the renal arteries, constantly convey a portion of the blood to the kidneys. This blood passes through the capillaries of the kidneys, and is collected into the renal veins that return it to the large vein that empties into the right auricle of the heart. As the blood goes through the capillaries, its watery part strains through their thin walls, carrying with it the various salts and gases from the blood. The water and other impurities pass out of the kidneys and collect in the bladder. See Fig. 47. With the average man, about fifty ounces of water and fifteen grains of urea are removed from the blood in this way daily.[1]

The lungs excrete much carbonic acid and watery vapor, with scarcely a trace of urea.

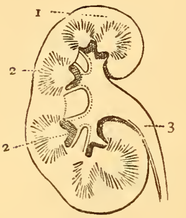


Fig. 47.

SECTION OF KIDNEY.—1. Body of Kidney. 2. Internal vessels. 3. Ureter, leading to the bladder.

The skin excretes much water and salts, with very little carbonic acid.

The kidneys excrete a great deal of water and salts, with but little carbonic acid.

110. Hygiene of Excretion.—The activity of all the excretory organs is absolutely necessary to health, to arrest any one of them is fatal. The principal ways of preserving their healthy action are to breathe freely of pure air, to keep the skin warm and clean, and to take sufficient exercise to keep the blood in proper circulation. The effects of imperfect excretion are languor, headache, loss of appetite, and inclination to fever. If the blood is not purified, the system becomes clogged, and the blood itself becomes loaded with the poisonous substances from the system. Diseases of the kidneys are of the most serious character.

NOTE.

1. Gains and Losses by the Blood.—The blood is constantly losing some of its parts, as follows: In passing through the lungs, it loses carbonic acid and water; in the kidneys, it loses water, urea, and salts; in the skin, it loses water, urea, carbonic acid, and salts; in the liver, it loses bile and other substances; by the repair of the tissues, it loses nutritious matter; by oxidation, it loses carbonaceous matter and oxygen; by radiation, it loses heat.

The blood is constantly gaining, as follows: In the lungs it gains oxygen; in the skin, oxygen; in the liver, sugar and other substances; from passing through the tissues, it gains impurities; from oxidation of food, it gains impurities; by oxidation, it gains heat.

The blood loses substances that are taken from it by the glands for secretions.

The blood gains nutritious substance from the digestion of food.

Suggestive Questions.

What is meant by excretion? How is excretion related to nutrition? What are the two great functions of the blood? What is the origin of blood impurities? How are the impurities taken from the tissues? How are the impurities taken from the blood? What is the structure of all excreting organs? What are the substances excreted?

Is it proper to say the blood is purified by the lungs? If not, what is better? What is the minute structure of the kidneys? How do they filter the blood? Why is the blood in the upper portion of the ascending vein purer than that in the lower portion? Why is the blood of the renal vein the purest blood in the body? What conditions favor excretion? How are the kidneys unlike the lungs and skin?

Topical Outline.

Excretion.

1. Definition.
2. Purpose.
3. Matter excreted.
   - *a.* Origin.
     - (1) Oxidation of carbonaceous food.
     - (2) Oxidation of waste tissues.
   - *b.* Kinds.
     - (1) Carbonic acid gas.
     - (2) Water.
     - (3) Urea and uric acid.
     - (4) Various salts.
4. General Plan.
   - *a.* Impurities absorbed by blood.
   - *b.* Impurities excreted from blood.
5. Organs.
   - *a.* Lungs.
   - *b.* Skin.
   - *c.* Kidneys.
6. Hygiene.

CHAPTER XI.

THE NERVOUS SYSTEM.

111. The organs of the body, such as the muscles, stomach, heart, and lungs, have no power of themselves to perform their important work. They are controlled and caused to work together by the nervous system. Through the nervous system we feel and move. It is through the nervous system that we think.

The nervous system, as shown in Plate IV, has certain great central parts, from which great numbers of tiny lines are distributed to the various parts of the body. By these centers and lines, all parts of the body are controlled.

112. **The Character of Nervous Tissue.**—The matter of which the nervous system is formed is unlike any other in the body. Nervous matter is three fourths water. It is a soft, white, pulpy substance, of extremely delicate structure. This nervous substance is very sensitive to touch. Close examination with the microscope shows that nervous matter is of two kinds: (1) The greater portion is white matter; (2) the less portion

Fig. 48.
Forms of Nerve Cells.

is grayish or reddish. The white matter is in the form of long, tubular fibers, about $\frac{1}{5000}$ of an inch in diameter. These are called nerve fibers. The nerve fibers are united, side by side, into cords, called nerves. The gray matter is in the form of tiny cells. These are called nerve cells. The nerve cells are collected into little knots or masses, called centers. Some of the nerve fibers begin in the skin and end in nerve centers; others begin in nerve centers and end in the muscles. Some nerve fibers connect nerve centers with one another. Nerve fibers conduct impressions to and from the nerve centers. The centers receive the impressions brought to them by the fibers, and send out impulses along the fibers leading from them.

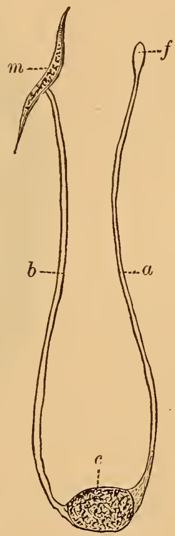


Fig. 49.

ELEMENT OF NERVOUS SYSTEM.—*a.* Sensory fiber. *b.* Motor fiber. *c.* Center. *f.* End of sensory fiber. *m.* Muscle.

The simplest possible arrangement of nervous matter that can perform complete nervous action must consist of one or more cells acting as a center, with a fiber leading to it, and one leading from it.[1]

In the accompanying figure, *c* is the center, *a*, the fiber leading to it; *b*, the fiber leading from it. If now the fiber *a* is irritated at the end *f*, the irritation is conducted to the center *c*. An impulse is now sent along the fiber *b* to produce motion in the muscle *m*. You may illustrate nervous action by your own feelings and motions. If any thing touches your finger, the ends of the fibers in the finger are irritated. This irritation is conveyed to your brain and you feel the touch. You now send an impulse from the brain along the fibers leading to the muscles, and thereby move your arm. In this way you experience the complete action of nervous matter.

113. **The general nervous system** consists of two subdivisions: (1) That part which aids in thinking, feeling, and moving; and (2) that which is engaged in controlling the vital organs. The first division is called the cerebro-spinal nervous system; the second is called the sympathetic nervous system.

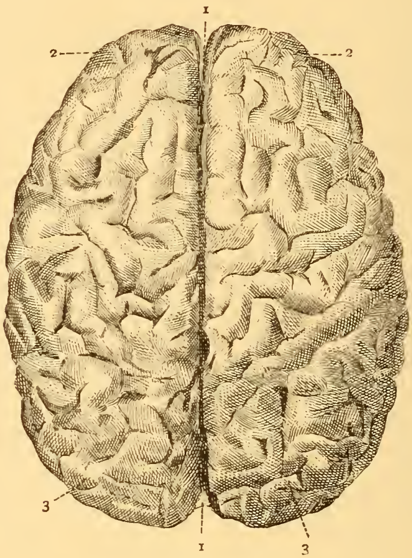


Fig. 50.

THE BRAIN SEEN FROM ABOVE.—1. Great fissure. 2. Anterior lobes. 3. Posterior lobes.

114. **The cerebro-spinal system** consists of the brain, the spinal cord, and the various nerves that connect these two with the skin and muscles. Through this system, we know when any thing touches us. Through this system, the mind learns the condition of the body. The mind controls the body through this system.

115. **The brain** is the chief nervous center. It is located in the skull, and is connected with all parts of the

body by the spinal cord and the nerves that originate therefrom. It is egg-shaped, with the smaller portion toward the front, and the larger portion fitting closely to the rear and lower portion of the skull. It weighs somewhat more than three pounds, or about $\frac{1}{40}$ of the entire body.[2] It is delicate, and sensitive to pressure, blows, and jars; hence it is securely

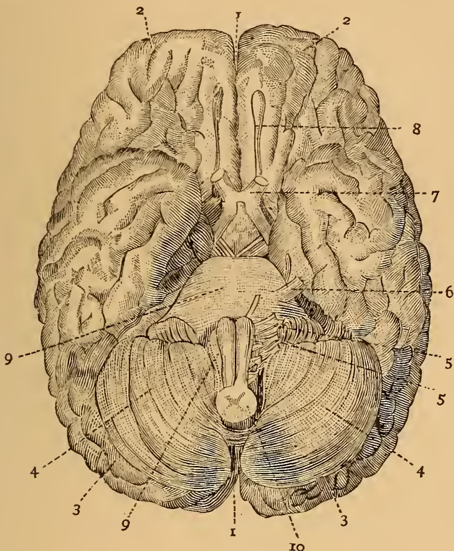


Fig. 51.

The Brain Seen From Below.—1. Great fissure. 2. Anterior lobes of cerebrum. 3. Posterior lobes of cerebrum. 4. Lobes of cerebellum. 5. Cranial nerves. 6. Auditory nerve. 7. Optic nerve. 8. Olfactory nerve. 9. Main body of medulla oblongata. 10. End of medulla oblongata.

protected by the strong, bony case in which it is lodged. Besides its bony box, it is covered with membranes, and surrounded by fluids for still further protection. The membranes that cover the brain are three: (1) A tough, dense membrane, which lines the walls of the skull; (2) a delicate membrane, packed about the brain; (3) a soft, fine membrane, that lies next to the brain substance, and supplies

the brain with blood. The brain, although $\frac{1}{40}$ the weight of the body, requires $\frac{1}{5}$ of the blood for its support.

The brain is separated, with the exception of a connecting portion at the base, into right and left hemispheres. This division is made by a deep fissure, extending through the middle, from front to rear. See Fig. 50. This division makes two brains, that are partially independent of each other.[3] The brain is also deeply folded and wrinkled. These folds are called convolutions. The brain is formed of both kinds of nerve matter, so arranged that the gray covers the entire surface to the depth of $\frac{1}{4}$ of an inch. The white matter is within, and connects all parts of the brain with the spinal cord at the base. The brain has three distinct parts: (1) Cerebrum; (2) cerebellum; (3) medulla oblongata. See Fig. 51.

116. **The cerebrum** is the brain proper. It forms about $\frac{7}{8}$ of the whole mass within the skull. It occupies the upper portion of the cavity of the skull, projecting forward over the eyes, and backward over the cerebellum. Its surface is deeply and irregularly folded, and, if spread out, would cover about five square feet. See Fig. 50. The cerebrum appears to be the part of the brain that enables us to think. The gray matter arranged upon its surface is the true source of nervous force.[4] The cerebrum presents many minor ganglia of gray matter at its base, and numerous arches and passages, the description of which can not be included in these brief lessons.

117. **The cerebellum,** or little brain, is situated under the rear portion of the cerebrum. It is closely connected with both the cerebrum and the medulla oblongata at the base of the brain. It is about $\frac{1}{8}$ the weight of the cerebrum. It is composed of both gray and white matter, arranged as in the cerebrum. Its folds are regular, and so arranged that when the mass is cut the section shows a curious leaf-like figure. This figure is called the arbor vitæ,

from its resemblance to the leaf of a tree by that name. The cerebellum appears to be designed to control the muscular movements.[4]

118. **The medulla oblongata** is that portion of the brain by which all the other portions are united into one mass, and the whole connected with the spinal cord. It forms the passage-way to and from the brain. It is the most exquisitely sensitive portion of the nervous system. From it arise several of the nerves of special sense, and some other nerves of peculiar importance. One of the nerves from the medulla oblongata passes out to the stomach and lungs. This nerve controls the process of breathing. The least injury to the medulla oblongata at the origin of this nerve causes instant death.[4]

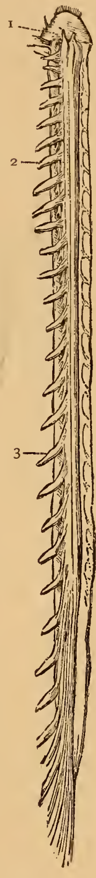


Fig. 52.
Spinal Cord.

119. **The spinal cord** is a continuation of the medulla oblongata into the opening provided for it in the spinal column. It is protected by the vertebræ and a continuation of the membranes that cover the brain. It is about fifteen inches long, and as large around at the upper end as the little finger. The substance of the cord is chiefly white matter, with some gray matter extending through the middle portion. Deep fissures, extending lengthwise of the cord, separate it into right and left halves. The cord connects the brain and the nerves of the body. In Fig. 52, we see a front view of the left side of the spinal cord, showing the origin of the spinal nerves; 1 is a portion of the medulla oblongata, 2 is the anterior fissure, 3 is the root of the eighteenth spinal nerve of the right side.

120. Spinal Nerves.—From the sides of the spinal cord, as a trunk, there originate thirty-one pairs of nerves, called spinal nerves. See Fig. 52. These nerves originate upon opposite sides of the cord, in nearly regular intervals along its entire course, and pass out through openings between the vertebræ at the sides of the column. Each nerve springs from the cord by two sets of fibers, called its roots, one set of which comes off from the front portion, and the other from the rear of the side of the cord. These two sets of fibers soon unite to form one nerve, which leads away to certain parts of the body. The fibers that come off from the rear of the cord are distributed to the skin. These are the fibers by which we feel, hence they are called sensory fibers. The fibers that arise from the front portion of the cord lead to the muscles. These are the fibers by which we move the muscles, hence they are known as motor fibers. The substance of the nerves is white matter. Each fiber of the nerve extends in unbroken line from the center in the cord, or brain, at which it originates, to the point at which it is to serve to give feeling or to produce motion.

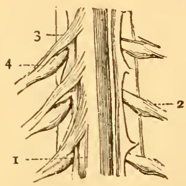


Fig. 53.

PORTION OF SPINAL CORD.—1. Body of cord. 2. A spinal nerve from left side of cord. 3. Anterior roots of a nerve. 4. Posterior roots.

This arrangement puts every part of the surface of the body in separate communication with the seat of feeling, and enables the mind to tell just where the body is touched. In like manner, the mind can move any particular muscle. The sensory fibers end in minute loops in the papillæ of the skin. The motor fibers end in the delicate covers of the muscular cells. By these two kinds of nerve fibers, the various portions of the body are connected with the brain, and the whole organism is enabled to feel and to move. See Fig. 53. For the general distribution of the nerves, see Plate IV.

Notes.

1. **Arrangement of Nervous System.**—The construction of the nervous system, and its manner of action, may be compared to the arrangement of a common electric battery used in telegraphy. The gray matter in the form of centers is like the battery cups in which, by chemical action, the electricity is generated, while the white fibers, that connect these centers and communicate with the skin and muscles, are like the telegraph wires, by which the messages are sent. The brain itself is like some central office, connected with a vast number of smaller offices and stations. At this center, news is constantly received from all directions, and, from this center, commands are sent out. The stimulus that is sent over the nerve fibers is like electricity, in many respects, and, by many students of physiology, it is thought to be electrical in character.

2. **Brain Weight.**—The human brain ordinarily weighs about fifty ounces, and is generally large in proportion to the highness of intellectual power in the individual, though this is by no means a necessary relation, for many persons of eminent mental superiority have had quite small brains, while a few very large-brained persons have been notoriously indifferent in mental power. Evidently much more depends upon the quantity of gray matter, quality of substance, and fineness of development, than upon mass. Among the results of examination of the brains of distinguised men, the following weights are given:

Cuvier	64.5	oz.	Abercrombie	63	oz.
Napoleon	53.	"	Schiller	63	"
Daniel Webster	53.5	"	Lord Campbell	53.5	"
Agassiz	53.4	"	De Morgan	52.7	"

3. **The Hemispheres of the Brain.**—Either of the hemispheres of the brain may be very seriously injured, yet the person live, and finally recover. Some years ago, in Indianapolis, a man fell from the top of a load of hay, and, by striking upon the prong of a pitchfork, the prong ran directly through one hemisphere of the brain, from front to back. The prong broke off, and remained for several hours through the brain. It was finally removed, and the person recovered, without serious injury to the nervous system or the mind. During the war of the rebellion, there were many cases of recovery from gunshot wounds, in which the bullet passed completely through one

hemisphere of the brain. A remarkable case of injury is upon record in which, in blasting with gunpowder, a pointed iron bar, three and a half feet long and one inch and a quarter in diameter, was driven completely through the side of the head of a man. It entered the skull below the temple, and made its exit at the top of the forehead. The man lay in a delirious, semi-stupefied state for about three weeks. At the end of sixteen months he was in perfect health, with the wounds healed and the mental and bodily functions unimpaired, except that the sight was lost in the eye of the injured side.

4. **The Divisions of the Brain.**—If the cerebrum is removed, as has frequently been done with birds and other brute animals, the animal may continue to live. It can stand or walk, it breathes, and digests its food, but loses all power of judgment—seemingly, it loses all mental activity. If the cerebellum is removed, and the remainder of the brain left uninjured, the animal appears to retain its mental faculties, continues its vital processes, but loses all control over its voluntary muscles. The medulla oblongata is too sensitive, and too intimately connected with the processes of breathing and circulation to admit of mutilation without causing death. The spinal cord may be cut, by which injury all communication is destroyed with the part of the body below the point of division. From these rude experiments, and from some other data, it is thought that the cerebrum is the part chiefly engaged in mental activity; the cerebellum, in controlling voluntary muscular motion; the medulla oblongata, in presiding over the vital processes; the spinal cord, in connecting the brain and body.

Suggestive Questions.

What are the uses of the nervous system? What are the uses of the cerebro-spinal nervous system? What are the uses of the sympathetic nervous system? What are the uses of the brain? What are the uses of the different parts of the brain? What are the uses of the spinal cord? What are the uses of the nerves? How do the gray and white matter differ? How does the human brain differ from the brains of brutes? How do we feel? How do we move?

CHAPTER XII.

THE NERVOUS SYSTEM. (*Concluded.*)

121. **The sympathetic nervous system** consists of a double chain of small nerve centers, located with one chain on each side of the spinal column. This chain extends the entire length of the trunk. There are many other centers located elsewhere. From these centers arise numerous nerve fibers, that connect the centers with one another, and with the various vital organs. Some of the fibers of the sympathetic system connect with the spinal cord and brain. By this general union, all the parts of the body are bound together as one organism. One of the members can not suffer injury or distress without causing all the others, even the brain itself, to

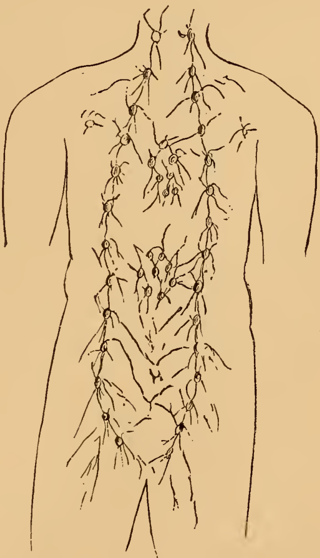


Fig. 54.

DIAGRAM TO INDICATE THE ARRANGEMENT OF THE SYMPATHETIC NERVOUS CENTERS AND FIBERS.

suffer also. Thus the stomach can not be deranged without distress to all the body. Pain can not exist in the heart without alarm to the whole body. One eye can not suffer without involving the other. It is because of this sympathetic union, established by this system, that it is called the sympathetic system. The numerous small centers of this system act somewhat as so many little brains, which control the action of the vital organs quite independently of the brain proper. The heart of a turtle will beat for a time after being cut out of the animal, because it has so many nerve centers in it that act to give it motion. See Fig. 54.

122. **The Function of Nervous Tissue.**—The fibers that have their outer ends in the skin are sensitive to touch and to changes in temperature. They convey the irritation they receive to the centers at their inner ends. In this way they cause an impression to be made on the centers. The impression made on the centers, especially on the brain, causes the mind to feel.[1] The impression made on the center may be so customary that the mind takes no notice of it.

The centers send out a nervous impulse along the fibers that lead to the muscles. These impulses sent to the muscles cause motion. If your hand touches a hot object, the ends of the nerves are irritated by the burn. This irritation is quickly conveyed to the brain. An impulse is sent to the muscles of your arm to move the hand away. The passage of irritation along the fibers is very rapid, so that the time is very short between the touching of the hot object and the taking of the hand away.

If the sensory fibers connecting any part with the brain are cut or seriously injured, there is loss of feeling in the part. If the motor fibers connecting any muscle with the brain are cut or injured, all power of motion in the muscle is lost. If both kinds of fibers are destroyed, both

feeling and motion are lost. These different conditions produce the various kinds of paralysis.[2]

123. **Reflex Action.**—The nerve centers may perform their action of sending out motor impulses without the conscious action of the mind. If the irritation is extreme, the centers act before the mind has time to consider and direct the movement. In the case in which your hand touches the hot object, you take the hand away instantly, before the mind has time to act. If any person sticks you with a pin, you flinch instantly. If you are about to fall, you instantly catch your balance. This action of the nervous system, in which the mind does not seem to act, is called reflex action.

If the spinal cord is cut so as to destroy all connection with the brain, the nerves connected with the gray matter of the cord will still perform reflex action. If the part of the body supplied by these nerves be burned or pinched, the part thus injured will be thrown into violent motion. In this case, the mind can not receive any feeling from the injured portion, and is wholly unconscious that the motion is produced. This is positive proof that the centers may give impulses that cause motion without the action of the brain. Such action is purely reflex.

The uses of reflex action are of the most important character: (1) It relieves the mind; (2) during sleep it continues the vital processes; (3) during the day it performs the usual acts of standing, walking, and working; (4) it conducts the operations of the sympathetic system; (5) it enables the mind to perform its usual acts with ease.

Reflex action not only directs the processes of the body, but largely invades the realm of intellectual and moral action. The whole matter of habit, whether of body or mind, is a manifestation of reflex action. As the nervous system acts once under certain conditions, so it is disposed to act again under similar conditions. By repetition, the action follows without thought.

124. Hygiene of the Nervous System.—Because all the other organs depend upon the nervous system for their control and energy, and because the mind, too, depends upon the activity of the nervous system, the health and vigor of the nervous system itself become a matter of great importance.

The nervous system may be naturally strong, or weak, because of the conditions of parents. Any kind of nervous disease in parents tends to produce corresponding feebleness in their children. This tendency is notably true of insanity, epilepsy, intemperance, licentiousness, and mania of all kinds.

Great waste of tissue and energy attends all nervous action. The nervous system, like all other parts, is dependent upon the blood for repair. Hence, it follows that faulty nutrition and impurity of blood result in nervous weakness. Impure air, by its effects on the blood, deadens the energies of the nervous system. Faulty excretion, by retaining the impurities in the body, acts similarly. The nervous system suffers through imperfect respiration, insufficient diet, and imperfect digestion. Many substances, which are often taken as food, drink, or medicine, affect the nerves by exciting or paralyzing them. Such is true of tea, coffee, tobacco, opium, alcohol, chloroform, and other articles of the same kinds.

Like all other organs, the nervous system requires proper exercise for its growth and continued vigor. The brain requires for its best development that the individual shall have proper physical exercise, so that the body may be strong. The brain, as the organ of the mind, requires proper mental exercise. The idle mind becomes weak. The nervous system and the mind are so closely related, that whatever affects one also affects the other. When the system is healthful and vigorous, mental action is most forcible and reliable.[6] Whatever weakens the nervous sys-

tem, or disturbs it, produces corresponding disturbances in the mind. What is known as insanity, in which case the judgment and reason are dethroned, is the result of nervous weakness, disease, or inflammation. Insanity may arise from lack of nourishment, prolonged exhaustion by disease, great fright, excessive grief, very great excitement, overwork, financial embarrassment, and other great strains on the nervous system. Insanity occurs most often as the result of heredity. In such cases, children inherit nervous weakness from their parents.

The nervous system needs proper rest. All other parts of the system are arranged with intervals of rest, alternating with action, during day and night. The cerebrum can not rest while awake, but requires a prolonged season of deep sleep. During sleep, the brain repairs itself. Without sleep, it becomes exhausted. If a person loses the sleep of one night, the brain is weak and restless, until the loss is repaired. Partial rest to the brain may be found in change from one kind of mental work to another. Recreation and amusement may relieve mental strain.

125. The Effects of Alcohol and Other Stimulants and Narcotics on the Nervous System.—Alcohol, when taken into the alimentary canal, is readily absorbed by the blood. The circulation of the blood quickly distributes the alcohol throughout the system, and brings it in contact with all the nerves of the body. The alcohol is attracted to nervous matter because of the large amount of water contained in the nerves and centers, for alcohol and water have great attraction for each other. The alcohol hardens the extremities of the nerves, and makes them less sensitive. The person loses the power to feel as acutely as he did before. We call this loss of feeling paralysis. The alcohol also inflames the nerve centers. For a short time after taking alcohol, the person seems stronger, the mind is brighter, the heart beats faster, the circulation of blood is

quickened, and the muscles are excited to action. This increase in the action of the system is called stimulation. Stimulation is followed by a season of corresponding depression, in which there is dullness, weakness, stupidity, and lowness of temperature. The effects of the alcohol on the nervous system are paralysis, irritation, and inflammation. If the quantity of alcohol taken be great enough, or if the effects are often repeated, nervous force becomes deadened, so that the person becomes unable to walk or to think. These depressing effects tend to cause death. It is because of these effects of alcohol on the nervous system that all medical writers call alcohol a narcotic poison.

The effects of alcohol on the mind are as follows: (1) For a short time it produces a pleasing feeling, in which the person seems bright and strong in mind, and the person is partly relieved from bodily pain; (2) following the first effects, the mind grows restless, is depressed, and suffers a craving for more stimulation. By the action of the alcohol on the system, the mind loses its power to perceive correctly, and to judge rightly. A person under the influence of alcohol is rash, careless, irritable, and dangerous. The influence is often such as to cause a complete change in the character of the person. Sometimes persons who, when free from it, are kind and gentle, become cruel and desperate; the refined and delicate grow coarse and vulgar.

The most serious injury that alcohol produces to the mind is that it tends to destroy the power of the *will*. Just as the person can not think so correctly, and can not feel so fully, so his power to control himself is weakened. No person can be more hopelessly wanting in self-control than an intoxicated person. Along with the weakened will, there is produced a craving for more stimulant. The person who uses alcohol is in danger of being led to use it to excess, and to form an uncontrollable narcotic appetite.

Added to the dangers and injuries to the person who uses

Plate IV.

NERVES.

THE STROBRIDGE LITH ... NATI

the alcohol, there is also danger of transmitting nervous weakness and narcotic appetite from parents to children. The children of parents who use alcohol and other stimulants generally suffer some kind of nervous weakness therefrom.

Intoxication is temporary insanity. It is not surprising that many repetitions of intoxication frequently lead to permanent forms of insanity. The use of alcohol is one of the chief causes of insanity.

Tobacco, like alcohol, is a poison. When chewed or smoked, its poisonous portion is absorbed by the blood and circulated through the system. Its effects are most fully shown in injury to the blood itself, and in paralysis of nervous force. Its influence on the nervous and muscular systems is so powerful that its use in medicine is regarded as too dangerous for general practice. Its use causes diseased conditions of the vital organs. The stomach, the liver, the heart, and the nervous centers suffer most from its use. The effects of tobacco blunt and degrade the mind. By its narcotic effects, its use fixes upon the system the most slavish conditions of the will. The person who permits himself to become addicted to its habitual use loses his power to stop the evil habit. No intelligent person, who uses it, will advise another to begin the use of it.

Tea and coffee affect the nervous system by causing stimulation. In their excessive use is to be found the cause of much headache, dispepsia, craving, and irritability of temper.

Opium is a gum made from the juice of the poppy. It may be smoked and chewed like tobacco. It is much used as a medicine, in the form of morphine. It allays pain, and produces deep sleep. If a sufficient quantity of the drug is taken, the sleep which it produces ends in death. These effects are caused by its powerful narcotic properties. Like alcohol and tobacco, it is a narcotic poison. Its use tends to produce an uncontrollable appetite. Persons who once form

the habit of using it, rarely ever escape from the craving that binds them to continue its use. Its habitual use causes the organs of the body to become diseased, and weakens and degrades the mind in an alarming manner.

Chloral hydrate and chloroform are drugs that are much used to relieve pain and to produce sleep. Their use is attended with the same dangers that apply to other narcotics.

The sleep produced by narcotics is not natural. While such sleep gives rest, it does not restore the body and mind as natural sleep does. Sleep caused by drugs is frequently followed by sick-headache and lassitude. The habitual use of sleep-producing drugs is a practice that tends to the most fatal results.

Notes.

1. **Sensibility of Brain Substance.**—The brain itself is insensible to touch, for when the skull is broken or cut away the brain thus exposed may be cut or torn without producing the least pain. Situated as it is within the dense skull, it is unprovided with sensory fibers. The substance of the brain is readily paralyzed by pressure; if the skull were fractured, so that a portion of the bone pressed upon the brain, the individual would lie in an unconscious state until such pressure was removed, and unless relieved would speedily die.

2. **Paralysis.**—From various experiments, it appears that the fibers that connect the brain with the body cross over from the left side of the brain to be distributed to the right side of the body, and from the right hemisphere of the brain to the left side of the body. By this arrangement an injury to the left brain, producing paralysis, will affect the opposite side of the body. The fibers of the cranial nerves do not cross over, so that an injury to one hemisphere of the brain may paralyze the eye and muscles of the face upon the same side with the hemisphere, and the nerves of the opposite side of the trunk and its extremities.

Suggestive Questions.

What is paralysis? Under what condition of the nervous system may we lose feeling from a part, but retain the power to move it? How may a part of our body move without our being conscious of its movement? What is sleep? What is pain? In what ways is pain useful? In cutting off an extremity, what parts, when cut, will give greatest pain? How does the shape of the head indicate character? How do narcotics affect the nervous system? How do impure air and indigestion affect the nervous system? What are the objections to the use of tobacco? What is the character of opium, hydrate of chloral, and chloroform?

Topical Outline.

Nervous System.

1. Character of nervous tissue.
   a. General structure.
   b. Kinds.
      (1) White, or fibrous.
      (2) Gray, or cellular.
   c. Function of each kind.
2. Divisions.
   a. General.
   b. Special.
3. General nervous system.
   a. Cerebro-spinal.
      (1) Purpose.
      (2) Parts.
         (*a*) Brain.
         (*b*) Spinal cord.
         (*c*) Spinal nerves.
   b. Sympathetic.
      (1) Purpose.
      (2) Parts.
         (*a*) Ganglia.
         (*b*) Nerves.
4. Function of tissues.
   a. Purposes of brain.
      (1) Cerebrum.
      (2) Cerebellum.
      (3) Medulla oblongata.
   b. Purposes of nerve fibers.
5. Reflex action.
6. Hygiene.
   a. Need of nourishment.
   b. Need of exercise.
   c. Effects of over-excitement.
   d. Need of rest.
   e. Effects of narcotics.
      (1) Alcohol.
      (2) Tobacco.

CHAPTER XIII.

SPECIAL SENSES.

126. General and Special Sensibility. — The mind learns to locate the feeling in the exact part of the body at which the ends of the nerves are touched. The feeling is really produced in the brain, and it is the mind that feels, but the mind locates the feeling at the outer ends of the nerves. For instance, if the right hand is burned, the feeling is referred to the hand and to the exact portion that is injured. For this reason, we say the hand feels.

The acuteness of feeling in any part depends on several causes: (1) The highly sensitive parts have a greater number of nerves extending to them; (2) the ends of the nerves in these sensitive parts are exposed so as to more fully receive the effects of the irritation; (3) the continued use that the mind makes of certain parts in feeling develops their sensitiveness.[1]

127. Pain.—When, from any cause, the nerves are very greatly excited, or are injured in their structure, the result is pain. Pain results, too, from the excessive use of any organ. Pain limits us in the use of our powers. Pain usually attends disease, and indicates what parts are suffering. Hence pain, though a present evil and greatly dreaded, protects us from danger, prevents us from using our bodies

too much, and warns us of the approach and presence of disease.

128. **Special Sensation.**—Some parts of the body are designed to give feelings from one cause, and other parts from other causes. The fingers touch, the tongue tastes, the eye sees, and the ear hears. All of these results are different feelings, coming from certain parts of the body. The mind learns by experience what these different kinds of feelings are, and learns also to tell something of the various causes that produce the feelings. In this way the mind gains different kinds of knowledge. These special adaptations of the nervous system to receive various kinds of feeling, are called the *special senses*. The special senses seem designed to give the mind its varied knowledge of the world. They are the windows of the mind, through which we look out, and gain knowledge of the things about us.

129. **The special senses** are feeling, tasting, smelling, seeing, hearing. The organs of special sense are, respectively, the skin, the mouth, the nose, the eyes, the ears. While each of these is very sensitive to the peculiar irritation which it receives, it is wholly insensible to the causes that excite the others. For instance, the eye may perceive the most delicate shade of light, but can in no way see the loudest sound; and the tongue, though able to detect the most delicate flavor, can neither hear nor see.

Each special organ of sense is supplied with special nerves; *i. e.*, nerves that are not used for any other purpose than for the peculiar feeling of that organ. These nerves lead to special nervous centers.

130. **Touch.**—The true skin, covering the entire body, is the organ of touch, because it gives the mind knowledge of the contact of things that touch it. The skin also feels the temperature of things. The hands are the special organs of touch. The hands are used to feel objects, and, from

the effects produced, the mind learns whether the surface be smooth or rough, warm or cold, hard or soft, and the like. By grasping the object, the hand fits about it, so that the mind learns the size and shape of objects held in the hand. By reaching out the hands and arms, the distances of bodies that are within reach is learned. It is by practicing the eye, in association with the hands, that the mind

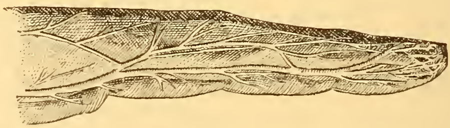


Fig. 55.

The Nerves of the Finger.

learns to judge of size, form, and distance.[2] Fig. 55 represents the nerves of the finger.

By its structure, the hand is adapted to be used as the organ of grasp and touch, and to serve the mind in many other ways, such as in writing, drawing, painting, sculpture, in performing on musical instruments, and in working at skillful trades. The hand is very flexible, so as to adapt itself to almost any shape. Its many joints, muscles, and tendons give it the greatest variety of motions. Its movements are easy, light, and rapid. Its location at the end of the arm permits it to touch any portion of the body. The two hands, acting together, perform thousands of the most intricate acts, and serve the mind and body in an untold number of ways.

131. **The Nerves of Touch.**—Any portion of the skin that possesses the sense of touch, consists of three parts: (1) A deep layer of fibrous tissue, (2) a delicate network of nerves running through the deeper layer, and (3) an outer, insensible layer, to shield the sensitive parts from

injury. Wherever the sense of touch is very delicate, as it is in the palms of the hands, and on the fingers, the deeper layer is raised into great numbers of closely-set points, about one hundredth of an inch in length, called *papillæ.* These papillæ project from the lower layer, and the insensible layer fills in between them, and covers their ends. The outer ends of the sensory nerves are in these papillæ. The papillæ are most numerous in the more sensitive portions; it is estimated that there are 20,000 of them to the square inch in the palms of the hands.

The acuteness of the sense of touch may be greatly increased by cultivation. This is true of all the special senses. By fixing the attention upon the feelings produced, the mind learns to understand more readily the sensations made on the brain, and to perceive differences that would not otherwise be noticed. The wonderful degree to which the education of the touch may be extended is well shown in the powers which the blind gain in learning to read freely from raised letters. These blind readers pass the tips of the fingers over raised print. By touching the words in this way, they recognize them as the ordinary reader does by seeing the word. To master a new word, they feel the letters, and spell it in that way. These blind persons also learn to perform skillfully on musical instruments, to do fine sewing, and to make many articles, requiring rare skill. They perform these difficult tasks by the education of their sense of touch.

132. **Taste.**—The various substances that are taken into the hand produce quite the same impression on the nerves of touch. If these substances be placed in the mouth, they affect very differently the sensory nerves of the mucous membrane covering the lips, cheeks, and tongue. They touch the parts of the mouth as they do the hand, and produce feelings of smoothness, softness, warmth, and the like, as they do in the hand. In addition to these feelings, some

of the nerves supplied to the mouth receive peculiar feelings from the objects that touch them. By these peculiar feelings, the mind learns the taste of any thing, whether it is sour or sweet, salty or bitter. In order that substances may be tasted, they must be moistened and dissolved, so as to come in contact with the nerves of taste. It is not all articles that produce taste, nor are all portions of the mouth supplied with these peculiar nerves. The parts that are most sensitive to taste are the outer end of the tongue, its border near the teeth, and the surface of the back portion.

133. **The tongue** is the organ of taste. The nerves supplied to it for tasting come from particular points on the medulla oblongata, and have their ends exposed on the surface of the tongue in a peculiar manner. The tongue is covered with great numbers of papillæ, which give to it a velvety appearance. In some parts, the tongue is covered with ridges. Toward the back portion, the tongue is supplied with numerous glands and sack-like depressions, which pour out their juices to dissolve the substances, and thus aid the nerves in tasting. The nerves of taste end in the papillæ of the tongue and about these glands. The border of the tongue seems most easily affected by sweets and sours; the back portion is most affected by salts and bitters. The impression made on the nerves of taste lasts for a brief season, so that a strong taste can not be immediately removed from the mouth.

By the habitual use of substances that have strong or pungent taste, we lose the ability to detect delicate flavors. The use of narcotics, such as tobacco and alcohol, deadens the sensitiveness of the nerves of taste. Very great delicacy of taste may be acquired by cultivation. Taste seems designed to guide us in the choice of food, and to lead to proper mastication. Brute animals, whose tastes are perfectly natural, are seldom misled in selecting food.

134. Smell.—The gases and vapors that pass into the nose with the breath come in contact with extremely delicate nerves. These nerve fibers end in the moist, mucous membrane that lines the upper portion of the nose. The substances that strike against these nerves produce peculiar effects, which the mind learns to know as odor, or smell. The nose is the special organ of smell. Every one is familiar with the fragrance of flowers, the savory odor of cooking meats, and the disgusting stench of decaying matter. These feelings, which we call smell, are probably produced by particles of substances that are floating in the air. These particles, upon being breathed into the nose, touch the nerves of smell. These nerves are called the olfactory nerves.

Smell seems designed to co-operate with taste in deciding our choice of food and drink. Smell seems particularly designed to detect impurities in the air. Smell is a more delicate sense than taste or touch. In some brute animals, this sense is astonishingly acute. The deer can smell the hunter many rods away. The hound follows the trail of a hare by the smell arising from the pressure of the hare's feet on the ground and grass. The hound may also follow his master's footsteps through the crowded street, hours after he has passed along, by the odor arising from the pressure of the master's feet on the pavement.

Evidently taste and smell are far more special in their nature than is touch, although they all depend on the contact of objects with certain nerves.

NOTES.

1. **Sensitiveness.**—The relative number of nerves in the different parts of the body may be measured by using a pair of dividers as follows: Place the two points of the dividers near together, and touch them to the tips of the fingers. We can detect the two points, even

if they are brought almost together. Now place the points against the back, and we shall find that we feel but one point. The two points may be separated an inch or more, and yet we can feel but one point in touching them to some parts of the back. This is because there are so few nerves on the back. Upon the cheeks, lips, fingers, or tongue, we can feel the two points, even if they are brought to within less than the twentieth of an inch. This is because the nerves are so much more numerous in these more sensitive portions.

2. **Judgment of Form and Distance.**—Without ever touching a round body, we can not judge of its form by the eye. A sphere has the same outline as the flat circle. Glass and water have the same appearance, and, to one who had never touched them, they would appear equally hard. To a young child, the moon is as near as the window, or as the chair. It is only by extending the arms and measuring distances that the mind finally learns to judge of distance through the eye.

Suggestive Questions.

Why does a tiny object appear to be so large when lodged in the eye? How does special sensation differ from general sensibility? How do we locate the exact spot upon the skin that is touched by any object? What knowledge do we gain through the agency of the hand? In what ways is the hand adapted for its uses? When the cuticle is removed, why does the skin beneath smart? Why does the warmth of the fire feel greater to the palm than to the back of the hand? Why may the special senses be so improved by practice?

How do the blind read? How does taste differ from touch? How does taste aid in protecting us? What protection does smell afford? How does the use of tobacco and alcohol affect the nerves of taste?

CHAPTER XIV.

SPECIAL SENSES. (*Continued.*)

135. **Sight.**—Light comes into our eyes from the things about us, and we see these objects. The light from a candle produces an effect on the nerves of the eyes, so that we see the candle. So the light reflected from the book causes us to see the book. This sense is called sight. By this sense, we learn to judge of the form, size, color, and distance of objects.

136. **The eyes** are the special organs of sight. There are two eyes. They usually act together, so that, in seeing anything, we use them both on the same object. We may see by using one eye alone. Persons who lose the use of one eye, learn to see with the remaining eye quite as well as others do with both. The eyes are placed very near the brain, in the deep sockets just under the front part of the cerebrum. By this position, the eyes are high, so that the person may see far, and, by the free movements of the head, the eyes may be turned quickly to see in any direction.

137. **The protecting parts** of the eyes are designed to prevent injury to these delicate organs. The bony orbits project around the eye, so that objects can not readily strike the ball. The brows and lashes shade the eyes from too much light, and prevent dust and sweat from entering the eyes. The lids close over the balls to shut out all light while

we are asleep, and, while we are awake, they keep the eye clean. The lining of the lids is a very sensitive membrane. If anything enters the eye, it gives pain to this membrane, so that the person has no rest until the object is removed.

138. **The Tears.** — The lachrymal glands are located in the eye sockets, just back of the outer end of the eye-brows. These glands secrete the tears from the blood and pour them upon the balls. The tears are constantly flowing into the eyes. They flow across from the outer upper corner to the lower inner corner, and pass into the nose through tiny ducts, opening into the nose for that purpose, called lachrymal ducts. The tears keep the eyes moist, and wash away the dust, so that the eyes are clear.

If anything gets into the eye to cause irritation, the tears flow in rapidly to aid in removing the object. In crying, the tears flow in faster than they can flow into the nose, so that they run over the edges of the lids. There are many little glands along the edges of the lids, that secrete an oily substance on the edge, to prevent the lids from sticking together, and to prevent the tears from flowing over.

The eye-balls do not fill the sockets, but are packed about by fatty matter, which forms a cushion for the eyes to rest on, and upon which to move freely.

The eyes are moved by muscles attached to the balls, and fastened to the back part of the socket. There are three pairs of muscles to each ball.

139. **The Eye-balls.**—By pressing the balls between the thumb and fingers, we find they are quite firm and hard. By taking the eye-ball of an ox to pieces, we shall find that it is filled with jelly-like fluids, surrounded by an outer shell or wall. The wall of the eye is formed of three layers or coats.[1] See Fig. 56.

The outer coat of the eye-ball is thick and tough. It is called the sclerotic coat. It forms the white of the eye.

This coat covers the front portion with a clear coat, called the cornea, designed to admit the light. This outer coat is designed to preserve the shape of the eye and to give it strength. The second or middle coat is the choroid coat. This lines the interior of the eye with a dense black pigment. In front, this second coat forms the iris, which gives color to the eye. Through the iris there is a round opening, called the pupil, to permit the light to enter the eye. The opening changes in size, growing smaller, so as to shut out some of the light when the light is too strong, and becoming larger as the light grows weaker. The inner or third coat is the retina. This is a thin membrane, covering the interior of the eye, and having the nerves of sight distributed through it.

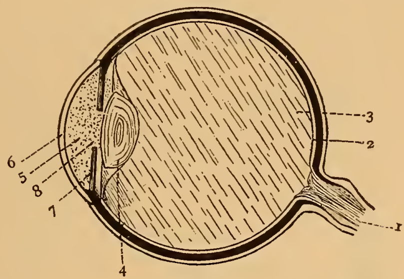


Fig. 56.

Section of the Eye.—1. Optic nerve. 2. Retina. 3. Vitreous humor. 4. Crystalline lens. 5. Aqueous humor. 6. Cornea. 7. Iris. 8. Pupil.

The jelly-like fluids that fill the eye are called humors. There are three humors: (1) The aqueous, which fills a small portion of the eye in front; (2) the crystalline, which is in the shape of a lens, about as large as a medium-sized button, just back of the aqueous humor; (3) the vitreous, which fills the main portion of the eye-ball. See Fig. 56.

The eye is supplied with special nerves of sight, called the optic nerves. These nerves enter the eye at the back portion of the ball, and spread out on the inner surface of the walls of the eye. These nerves cover only the back portion of the interior, where the light that enters the pupil falls.

140. How We See.—We do not touch the thing we see, as we do the objects we taste. Instead of having the objects come into our eyes to touch the nerves of sight, the nerves of the eye are so delicate that they are affected by the light that comes from the object into the eye through the pupil.

Light is a kind of wave-like motion, and, in coming against the delicate nerves, irritates them. The light passes off in all directions from objects in diverging straight lines. Some of these lines of light pass in through the pupil. In passing through the crystalline lens, they are so turned from

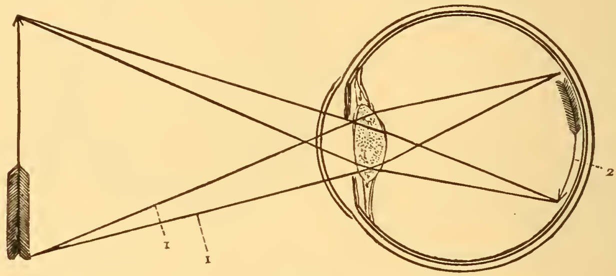


Fig. 57.

DIAGRAM OF THE EYE.—1. Lines of light from end of arrow. 2. Small, inverted image in the eye.

their course that all the rays or lines that come into the eye from any point on an object are brought together at one point on the retina, and all the lines from any other point of the object we see, are brought together at another point on the retina. It is in this way that there is a complete image of the object we see made on the retina. See Fig. 57. This image is very small, but is bright, and has the shape, shade and color of the object seen. From this image on the nervous membrane of the eye, the mind learns to judge of the shape, shade, and color of an object, just as it judges of an object by taste or smell.

The image is so small that it seems wonderful that the

mind can use it so perfectly. It may be that the whole landscape, which covers many miles in extent, is pictured in an image on the back of the eye, so small that it would not cover more than the surface of the little finger-nail. The mind, however, can fix its attention on any point in this image, and see the same point in the landscape. From the point that is affected in the eye, the mind learns to judge of the direction of the light and of the direction of the object that is seen. By practice, we learn also to judge of the size and distance.

The image in the eye is wrongside up, but the mind has learned by experience to judge of the object as erect.

141. **Near-sightedness.**—The crystalline lens brings the rays of light together on the retina to form the image. If the lens is too nearly round, it brings the rays together before they reach the retina, so that no image is formed. Persons having such eyes are said to be near-sighted, because they can only see objects that are very near the eyes. This defect of the eyes may be remedied by wearing concave glasses, to counteract the roundness of the crystalline lenses.

142. **Far-sightedness.**—If the lenses are too nearly flat, the rays of light are not brought together upon the retina, so that no image is formed. Persons with such eyes can see only distant objects. They are said to be far-sighted. Many old persons are far-sighted. This defect of the eyes is relieved by wearing eye-glasses that are convex, so as to bring the rays of light together, to form an image on the retina.

143. **Hygiene of the Eyes.**—The eyes may be injured by looking at objects that are very brilliant. To look directly at the sun is painful and injurious. By straining the eyes in trying to see in light that is too feeble, the eyes are injured. To read or sew by faint light injures the eyes. The light, in reading, or in other cases in

which the eyes are used continuously on the same object, should come upon the page, from the rear or side of the person. By this means, the direct light does not enter the eyes, but the light is first reflected from the object, and then enters the eye.

The eyes may be injured by using them too intently, or too continuously, on very fine work of any kind. To prevent injury in this way, the eyes should be rested and relieved by being used in other ways.

If, from any kind of use, the eyes become inflamed, the best relief is to give them perfect rest. Keep them closed, wear colored glasses for a time, or remain in closed or shaded rooms, if necessary.

If an object gets into the eye and causes pain, remove it promptly, by lifting or turning the lid, and taking the folded corner of a soft handkerchief, or the rounded end of some smooth object. Do not rub the eye, nor wipe it excessively, for such practices will increase irritation.

Keep the eyes clean by thorough washing in clear water.

Note.

1. **Dissection of an Eye.**—The structure of the eye may readily be seen by cutting open the eye of a beef or hog. Take the eye from the socket immediately after the animal is killed. With a pair of sharp scissors trim away all muscle and fat from the ball. The optic nerve may easily be seen at the back portion, very nearly opposite the pupil in front. Hold the ball firmly in one hand, and by careful pressure push the sharp point of the scissors through the back part of the eye. Having done this, cut forward to the margin of the cornea. Turn the eye, and cut in the opposite direction in like manner. The ball may now be turned "inside out." The vitreous humor may be removed into a dish, and the crystalline lens may be taken out. The coats may be examined, and all the parts exposed to view. Take the lens between the thumb and finger and use it as a magnifying glass. Hold the lens in front of the

window, about twenty feet away, and place a piece of paper half an inch behind the lens for a back-ground. In this way, you may obtain a small bright image of the window. These simple experiments illustrate the uses of the lens in the eye.

Suggestive Questions.

What is it that we feel in seeing any thing? Is there an image in each eye? If there is an image in each eye, why does not every object seem double? What advantages are gained by having the eyes placed where they are? What are the eye-lashes for? From where do the tears come? What are tears for? How may we examine the structure of the eye? The iris of the cat's eye is nearly closed in the day time, but is wide open at night; why is this so? What is light? If the image is wrongside up, why does not the object appear so? Why do old people wear eye-glasses? How are we liable to injure the eyes? If the eyes become weak, what is the best treatment for them?

CHAPTER XV.

SPECIAL SENSES. (*Concluded.*)

144. **Hearing.**—The ear is the special organ of hearing. There are two ears. They are less closely related than are the two eyes. For protection, the ears are located at the base of the skull. The internal portion of the ear, which is the most important part of it, is inclosed in a very hard part of the skull, called the petrous bone.

The ear has three parts: (1) The outer, (2) the middle, (3) the inner. See Fig. 58.

The outer ear includes: (1) The shell-like part that projects from the side of the head; and (2) the canal, or air tube, leading into the middle ear. The shell-like part is called the concha. It is formed of thin cartilage, covered with skin. It catches the sound, and directs it toward the inner parts of the ear. The canal leading from the concha is an opening through the petrous bone, lined with skin. It is about one fourth of an inch in diameter, and an inch long. It is an air chamber, and conducts the sound toward the inner ear. The inner end of this canal is closed by a membrane, which is stretched tightly across it. This canal is called the external auditory canal.

The middle portion of the ear is called the tympanum. It is an air chamber in the petrous bone, about as large as a small cherry. Its outer wall is formed by the thin mem-

brane across the end of the external canal. This is called the external membrane of the tympanum. Sometimes it is called the outer drum of the ear. There are other, smaller membranes, on the side of the tympanum, next to the inner ear, which separate the middle from inner portion of the ear. The outer membrane of the tympanum, and one of the inner

Fig. 58.

DIAGRAMATIC SECTION OF LEFT EAR.—1. Concha. 2. External canal. 3. Middle ear, crossed by the ossicles. 4. Inner ear. 5. Petrous bone. 6. External membrane of the middle ear. 7. Eustachian tube. 8. Auditory nerve.

membranes are joined by a very crooked line of tiny bones, called the ossicles of the ear.[1] A small air tube, called the eustachian tube, or internal auditory canal, leads from the tympanum to the pharynx, so that the air in the tympanum may pass in or out. The tympanum is to convey the sound from the outer to the inner ear.

The inner ear is a very singularly-shaped chamber in the petrous bone. This chamber is filled with a watery fluid,

and has in it the membranes on which the nerves of hearing are spread out. It is the most important part of the ear. The other portions may be destroyed, and yet the person can hear quite well by this portion alone. This inner ear consists of several parts, which seem designed for different purposes in hearing.[2]

145. **How We Hear.**—As in seeing, so it is in hearing. The objects which produce the sounds we hear do not come into the ear and touch the nerves of hearing, but sound comes from them into the ear, somewhat as light comes into the eye.

146. **Sound.**—When any elastic body, such as a bell, drum, or piano string, is struck, it vibrates very rapidly. The air which surrounds the vibrating, or sounding body, is elastic too, and is caused to vibrate as the bell does. The vibrations in the air pass out from the bell in all directions in waves. If these waves enter the ear, and cause the air of the outer ear to vibrate, the vibrations will be conveyed through the tympanum to the inner ear. The watery fluid of the inner ear will vibrate in like manner, and thus irritate the nerves of hearing so as to produce those sensations on the brain that the mind learns to know as sound. By practice, the mind learns so tell much about the nature of the sounding body, to tell its direction, and something about its distance.

147. **Hygiene of the Ears.**—The ear is more liable to disease than the eye is. Inflammation of the throat often affects the ear through the eustachian tube. It is sometimes injured by the lodgment of objects in the outer ear. The bitter wax of the outer ear is designed to protect the ear from insects. This wax will come out of itself, so that the person need not try the experiment of picking it out. The ear should not be exposed to great cold, nor to draughts of cold air. Deafening sounds sometimes injure the ear. Under no circumstances should any one be struck on the

ear. To strike the ear with the hand, or with a book, is liable to injure the tympanum seriously.

Deafness is a very great misfortune. The mind loses one of its chief organs of sense in losing the hearing. It is through hearing that we learn to use language. Any one who is born deaf, is dumb also. Any one who loses the sense of hearing, soon loses the power to modulate the voice, for the voice is guided by the ear. Such persons suffer great loss of enjoyment.

Notes.

1. **The bones of the middle ear** form a very irregular chain of bones, connecting the external membrane with the membrane of the inner ear. They seem designed to aid in hearing, by forming a better means of transmitting the waves of sound. They may be removed, and the hearing be retained. There are four of these little bones in each ear: (1) Mallet, (2) anvil, (3) orbicular, and (4) stirrup. They are joined by cartilage, and are acted upon by small muscles that enable us to make the chain press firmly against the membranes, as we do in straining the ear to hear sounds that are difficult to catch.

2. **The inner ear** is the essential part of the organ. It is a cavity filled with fluid. This fluid is water, with some salts dissolved in it. The cavity is exceedingly complex in shape, and presents many winding canals and passages. Floating in the fluid that fills the cavity, there is a sack, upon the walls of which the ends of the auditory nerves are exposed. The auditory nerve enters the inner ear from the rear, and sends its various fibers to the different parts of the cavity. Near the membrane, against which the stapes, or stirrup bone, fits, the cavity of the inner ear is large. This large part seems designed to receive the ruder sounds. The cochlea of the inner ear contains a thin, bony plate, triangular in shape, across which are drawn nerve fibers of different lengths, somewhat like the wires of the harp or piano. This portion of the ear seems designed for the appreciation of musical sounds.

Suggestive Questions.

Why do we have two ears? What are the parts of the ear? Which part is the real ear? How are we liable to injure the ear? What is sound? Which affects the mind the more, blindness or deafness?

Topical Outline.

Special Senses.

1. Sensibility.
   - *a.* General sensibility.
   - *b.* Portions especially sensitive.
   - *c.* Excessive irritation produces pain.
     - (1) Causes of pain.
     - (2) Uses of pain.
2. Special senses.
   - *a.* Touch.
     - (1) Possessed by the skin.
     - (2) The hand is the special organ.
       - *a.* Adaptation of hand for touch.
       - *b.* Ideas gained through touch.
       - *c.* Education of the sense of touch.
   - *b.* Taste.
     - (1) Limited to the mouth.
     - (2) The tongue is the special organ of taste.
     - (3) Uses of the sense of taste.
     - (4) Education of taste.
     - (5) Injuries to taste.
   - *c.* Smell.
     - (1) The nose is the special organ.
     - (2) The uses of the sense.
   - *d.* Sight.
     - (1) Nature of light.
     - (2) The eye.
       - (*a*) Protecting parts.
       - (*b*) Eye balls.
         - (1) Coats.
         - (2) Humors.
         - (3) Muscles.
     - (3) Theory of seeing.
     - (4) Defective vision.
       - *a.* Near-sightedness.
       - *b.* Far-sightedness.
     - (5) Causes of injury.
     - (6) Means of recovery.
   - *e.* Hearing.
     - (1) Nature of sound.
     - (2) The ear.
       - (*a*) Outer.
         - (1) Structure.
         - (2) Uses.
       - (*b*) Middle.
         - (1) Structure.
         - (2) Uses.
       - (*c*) Inner.
         - (1) Structure.
         - (2) Uses.
     - (3) Theory of hearing.
     - (4) Liability of organ to injury.
     - (5) Care of organ.

CHAPTER XVI.

ELEMENTARY SANITARY SCIENCE.

148. **What and How to Eat.**—The effects of food upon the health are direct and powerful, for the food either nourishes and revives the system, or it may, by its unfitness, cause disorder and disease.

If the quantity taken is much in excess of the demands of the system, evil consequences follow. Over-eating produces dullness, heaviness, and tendencies to sleep. Overtaxing the digestive organs, deranges their action and causes dyspepsia. Excess of food in the intestines, causes irritation.

If too little food is eaten, the strength of the system fails. The mind, too, loses in force.

One who labors needs sweet, light bread, lean meat, eggs, milk, beans, and similar articles of food. Fruits and grains serve well for those who labor less violently, and to complete the diet of the laborer. Avoid heavy bread, rancid or offensive butter, sodden potatoes, tainted meats, foods fried in grease, excessive quantities of pickles and condiments.

The system is disposed to accommodate itself to custom. If the meals occur at regular intervals, the digestive organs will find proper seasons of rest and action. Hurried eating is an evil. The food bolted into the stomach, partially chewed, gives to the stomach a task for which it is unfitted. Food

thus eaten, gives little satisfaction, and often proves to be a source of irritation.

If food is eaten under mental depression, ill-humor, or anxiety, digestion does not proceed as well as if the food is eaten in cheerfulness, deliberation, and peace. The surroundings of the table and room need to be graced with cleanliness and taste. Each person needs to learn for himself what food best suits his needs. All need to observe the following simple rules: (1) Eat liberally and regularly of plain food; (2) eat deliberately, and with pleasant surroundings; (3) eat sparingly of highly-seasoned mixtures; (4) cease eating before the appetite is entirely satisfied, rather than eat too much.

149. **What to Drink.** — The system demands water. This demand is more urgent than the want of food. All substances added to water affect its purity and usefulness as drink. Of pure water, a person is not disposed to drink too much, and there are no serious consequences from an excess of water in the system. Water is easily excreted, and does not tend to inflame or irritate. Too little water causes thirst, which will give no rest until relieved.

Dangers arise from the impurities contained in the water we drink. Water containing much mineral salts, such as lime, iron, or common salt, is unfit for use. Water having bad odor or taste, or water that is colored, or water that will produce a scum when boiled, is unfit to use. Dyspepsia, dysentery, diarrhea, and typhoid and malarious fevers are often caused by the use of impure water. When pure water can not be obtained, the water that is used should be filtered or boiled.

Much drink at meal time weakens digestion. Much tea and coffee dilute the juices of the stomach by the amount of water they contain. They affect the nervous system by the stimulants they contain. They tend to deaden the nervous sensibilities. The fact that these substances produce

a craving so strong that persons who use them habitually find it difficult to cease using them, shows how decidedly they act on the nerves.

A moderate quantity of warm drink, taken with the food, may assist rather than retard digestion. If the food is eaten deliberately, there will be little call for copious drinks of of water, milk, tea, or coffee. To drink hastily large quantities of cold fluid deranges digestion. Ice water is too cold for use.

To use beer, wine, or whisky, in any of their forms, is useless and dangerous. The craving which these substances beget in the system, is a sure evidence of their powerful narcotic influence.

150. The Clothing and Cleanliness.—Properly nourished and cleaned, the system is healthy and vigorous. If either of these two processes is arrested, or is imperfectly performed, the result is weakness and disease. Disease is not something which comes upon us from the outside, but is the result of faulty nutrition or defective removal of waste matter.

The skin is specially engaged in the excretion of matter. To keep the skin clean, by proper bathing and clothing, is to keep open one of the chief outlets from the system. The warm bath with soap, followed by brisk rubbing, opens the pores and removes the waste matter from the surface. Exercise in the sunlight and fresh air enlivens the skin.

The clothing absorbs the impurities from the skin, and becomes loaded with them. Especially is this true of the under-clothing. The garments worn next to the skin should be frequently removed, washed, and aired. The same is true of the clothing of the bed.

Warmth is better attained by putting on several layers of light, loose-fitting garments, than by fewer layers of heavy clothes. The clothing should be loose, because it is warmer, and that it may not press the body out of shape. Tight

clothing prevents free circulation of the blood, by pressing on the arteries and veins. Clothing that fits closely about the waist should not be worn, because it hinders the fullness of breathing. The weight of the clothing should be borne by straps across the shoulders, rather than be supported by tight bands about the waist.

The clothing should protect the extremeties. The exposure of hands, wrists, feet, ankles, and legs is a frequent cause of congestion and "cold." Children who are well clothed grow more rapidly and more fully than those who are not. The naked legs and arms, and the tight waists of children, which so please the vanity of silly mothers, are at the expense of the health and development of the children.

A few suggestions are worthy of repetition: Keep the skin clean; dress the body warmly; change the clothing frequently, especially the underwear; avoid damp clothing; exercise much in the fresh air and sunlight.

151. **Breathing and Pure Air.**—The proper oxidation of the blood depends on the purity of the air and the fullness of respiration. If we keep the chest large, and breathe deeply, we shall obtain more oxygen than if the lungs are compressed in any way. Tight clothing about the chest prevents the chest from expanding, and, therefore, causes us to breathe less air. Such clothing also prevents the lungs from developing, and makes them small and feeble. If we sit or stand with the shoulders drooped forward, the chest is diminished in size, and less air is breathed; we should, therefore, keep the shoulders well back, and sit or stand in an erect position.

The in-door air of houses is less pure than the free air outside. The oxygen within is rapidly consumed by the breathing of the inmates, and by the burning of fires, lamps, and gas-jets. Impurities are thrown into the air by the breath, and the escape of other waste matter from the

bodies of persons. Lamps usually throw their impurities into the air of the room. Other impurities arise from the cooking and the decomposition of substances.

The outdoor air is usually pure. In order that there may be sufficient interchange of the air within with that which is without, there must be ventilating passages. The good health of the inmates is impossible without ventilation.

Those who live exclusively in-doors can not be so healthy, robust, and vigorous, as those who live more in the open air.

The breathing of impure air tends to cause headache, drowsiness, languor, mental confusion, and loss of appetite. Persons who breathe impure air become pale, chilly, and feeble. The breathing of pure air produces warmth, gives a rosy tinge to the skin, causes clearness of mind, sharpens the appetite, and increases the general activity of the system.

A few words of advice are worthy of being remembered and heeded: Do not close the sleeping and sitting-rooms so that no fresh air can enter; breathe fully; keep the shoulders back, and the chest extended; live much in the open air.

152. **Occupation.**—It is the universal experience, that regular exercise tends to promote health. Those who have work to do are usually more regular in their habits, both of body and mind, than are those who are idle. The laborer is usually blessed with a keen appetite; indigestion gives him little trouble. He rests well, and is free from the many imaginary pains and ills that afflict the idle. Diligence and industry give peace of mind, and tend to long life.

It is by proper exercise and nutrition that any part of the body is made strong. The laborer is strong; the idle person is usually weak. The muscles of the working man are hard and dark, those of the idler are soft and pale. The mind

of the workman is clear and forcible, the mind of the idler tends to confusion and feebleness.

It is not all kinds of occupation that conduce to health. If the business in which any one is engaged is exclusively of one kind of work, and calls into action only one part of the organism, while other parts suffer from inaction, the occupation may be injurious rather than beneficial. Workmen who perform their labor in crowded factories, or in rooms that are illy lighted or ventilated, may suffer disease from too close confinement. In many kinds of industrial pursuits, the workmen are compelled to inhale injurious dust and gases produced from the substances in which they work. Such persons frequently suffer disease from these causes. In many kinds of business, workmen are compelled to sit or stand, with little exercise, during the entire day. Sedentery employment should be preceded and followed by long walks in the open air.

Whatever be the circumstances, a person needs something regular to do. The task needs to be one that engages the energies of both body and mind in a way that is pleasant to the individual. Besides the manual labor that each may profitably perform, great benefit will come from giving a short time daily to the pursuit of some kind of study, or artistic avocation, that shall gratify the higher wants of the mind. A person who can each day devote a short time to the gratification of some taste for the pleasing or beautiful, will feel a keener relish for life, than he who gives the whole time to drudgery or idleness.

In connection with occupation, which shall provide regular hours for labor, there needs to be found time for recreation. "All work and no play" tends to make the person dull. A few minutes of amusement, of play, or delightful freedom, invigorates the whole being.

Strength of body and mind requires that they shall be used, rested, and recreated. Diligence is a powerful

barrier to disease. Idleness opens the gates for a score of ills.

153. **Habits.**—Both the body and the mind are disposed to repeat former actions under like circumstances. It is in this way that we form habits; *i. e.*, by doing a certain thing, we are disposed to do it again, and, by repetition, the tendency to do it becomes so strong that it is difficult for us to avoid doing it. It is in this way that we learn to perform difficult tasks easily. Some movement of our hands may be difficult at first. If we repeat the effort many times, the movement becomes quite easy, and, finally, we may perform the action without giving it any thought.

In like manner, the system is easily impressed by substances that have peculiar effects on the nervous system. By using small quantities of tea, coffee, alcohol, tobacco, or opium, we may form a demand for them, until we find that our system craves them. At first the system may reject the substances, yet repetition may cause us to lose our dislike, and, finally, to enjoy their influence. At first tobacco causes nausea, but, by repetition, the person learns to like it, and at last becomes a slave to the use of it.

By neglect, we may form evil habits that lead directly toward disease; whereas, by attention, we may form such habits as shall lead to health. By persistent effort, we may correct our evil habits, and substitute for them tendencies toward good. One who uses tobacco, may lessen the amount gradually, and, by firm resolution, refrain from its use until the system becomes accustomed to doing without it.

Even if we fail at first to accomplish a desired end, we may have so gained in strength by the effort that later attempts may prove successful. There is reason for great faith in final success in all efforts to correct evil propensities. It is by neglect and repetition that what is evil and injurious gains dominion over us.

154. Care of the Sick.—The room in which a person is sick should be well-lighted, without the direct light paining the eyes of the sufferer. The room should be well ventilated, without the draught of air being felt by the invalid. A thermometer should be employed, by which to tell the temperature. The temperature should not vary much from sixty-eight degrees.

The room should be free from noise and excitement of any kind. There should be no bustle of cleaning; no slamming or creaking of doors; no mysterious whisperings. Whatever is said in the room should be told in an ordinary tone of voice.

The bed should be comfortable, and the patient be as little disturbed in position as possible. The clothing of the bed should be kept clean, and every thing offensive be removed promptly from the room.

The patient's food should be prepared in a plain but inviting manner, without tempting the appetite. Trust to nature to manifest her wants. The invalid is not hungry, and is quite likely unable to digest food. Small quantities of easily digested food, taken quite frequently, are usually better than to take larger quantities at a time.

The nurses need to act naturally, and not to tire the patient with anxious movements, restlessness, and officious care. Trained nurses, who have in mind simply the faithful discharge of duty, are to be preferred to persons whose excessive anxiety unfits them for the quiet care of the sick person.

The sick one needs peace of mind, quiet, and rest; these can only be afforded by quiet nursing. Medicine may be needed at times, to assist nature in recovery; usually, however, proper rest, cleanliness, plain nourishment, and relief of mind are the chief agents in recovery.

When the patient becomes convalescent, he needs to be guarded against excessive exercise, against too much

excitement, and against immoderate eating. "Make haste slowly" in recovery.

Those who serve as nurses should be careful to rest themselves at regular intervals, to eat regularly and liberally, and to avoid all excessive anxiety of mind. Nursing the sick is laborious service, at which a person may easily over-work.

155. **General Suggestions.**—To maintain good health, we should observe the following suggestions:

1. We should take a proper amount of exercise.
2. We should take proper rest and sleep.
3. We should eat liberally of plain, good, well-cooked food.
4. We should use pure water.
5. We should breathe fully of pure air.
6. We should attend regularly to the excretions from the body.
7. We should keep the skin clean.
8. We should wear clean clothing, that will protect from heat or cold.
9. We should wear such clothing, and maintain such position, as will give the body entire freedom of action.
10. We should avoid chill, and not wear damp clothing. The feet and hands should be kept warm and dry.
11. We should be regular and moderate in all our habits.
12. We should keep the mind at peace with itself and with all men.

Suggestive Questions.

How may disease result from the food we eat? What substances should we avoid as food? How is the appetite affected by the mind? What rules would you give about eating?

What dangers are connected with drink? What diseases often arise from drinking impure water? How may we judge of the purity or impurity of water? How may impure water be purified? What

are the objections to the use of tea and coffee? Why should we not use beer, wine, or whisky?

What is disease? Does it come upon us from within or from without? What are the great causes of disease? Why should we keep the skin clean? Why should we wear clean clothing? Which clothing needs the greater care, the underwear, or the outer garments? Why should we wear loose clothing? Why should the clothing be supported by straps over the shoulders? How does improper clothing hinder the growth of children? What special objection is there to the wearing of damp clothing?

How may we enlarge the lungs? Why are in-door dwellers less robust than those who live much in the open air? What are the diseases that are caused by impure air? What rooms require special attention in ventilation? Give three directions as to the manner of breathing.

What effect has regular occupation on the health? How do diligence and industry affect the mind? Why are idlers usually dissatisfied? In what way do some kinds of occupation prove to be unhealthful? What need is there of recreation? Why should we play?

What is habit? How are habits formed? How may we overcome bad habits? What is gained by trying, even if we do not succeed?

How should the room of a sick person be lighted? How should it be aired? What need is there of a thermometer in it? What should the attendants avoid? What directions need to be observed about the bedding? How should the food for the invalid be prepared? How should the nurse behave? What enables the sick person to get well? When the invalid is getting well, what mistakes is he liable to make? What care should the nurses take of themselves? State twelve directions for keeping well.

CHAPTER XVII.

EMERGENCY AND ACCIDENT.

156. **In case of sickness,** seek a comfortable room, well lighted and ventilated. Keep warm, clean, and quiet. Usually the system will recover its natural condition quite soon if undisturbed. Do not be too anxious, nor treat yourself with copious amounts of medicine. If you are very ill, send for a competent physician, and wait quietly for his arrival.

157. **If serious accident** occur, place the unfortunate person in the most comfortable position possible, with sufficient fresh air and warmth. Relieve acute pain by applying hot or cold compresses to the injured part, as may feel most agreeable to the sufferer. Send for a surgeon, and send such information as may enable him to judge what appliances to bring with him.

158. **If bones be broken,** joints dislocated or sprained, place the injured part in the least painful position. Keep the part quiet. Relieve acute pain by applying hot or cold water. Keep the feet warm. Obtain the services of a surgeon, to replace the parts in their natural position, and to apply bandages for retaining them in place.

159. **If wounds be made** which bleed rapidly or in jets, pressure must be made upon the veins or arteries that

are cut. Pressure may be made with the thumb, or with a knotted handkerchief bound around the limb, so that the knot rests over the vein or artery; after tying the ends, twist the handkerchief tightly. If the bleeding is from an artery pressure must be made between the wound and the heart; but, if from a vein, make pressure at, or beyond, the wound.

If the bleeding is moderate, bathe the wound freely with cold water, place the edges of the parts together naturally, and retain them in this position with strips of sticking-plaster and light bandages. Keep the wound quiet, that it may heal. Avoid salves and ointments.

160. **In burns and scalds**, cut the clothing quickly and gently away, and coat the injured part thoroughly with water and flour, water and soda, or sweet oil and cotton. Immerse the part in cold water, if convenient. Do not apply salves and ointments. Keep the injured part clean and quiet.

161. **In cases of apparent death by drowning**, treat the case at once. Strip the clothing from the throat and chest. Apply diluted ammonia to the nostrils at intervals. Place the person gently on the face, with the forehead resting on the arm, so that the entrance to the windpipe may be open. Turn the body upon the side, and again upon the face, alternately, every four seconds. When the body is turned upon the face, make gentle pressure over the chest to aid in expelling the contents, and remove such pressure upon turning the body on the side, in order that the chest may fill with air. Persevere in this movement for two or three hours, or until the patient begins to breathe. Chafe the skin, and rub the limbs firmly toward the heart. Remove the wet clothing of the sufferer, and replace it with warm, dry wrappings of any kind.

162. **In cases of suffocation** from foul air, remove the body into fresh air, and treat as for drowning.

163. **In cases of unconsciousness from cold,** rub the body with snow, or place it in water for a short time. Rub briskly, until dry. Keep up warmth by friction. Keep the patient in a cool room. Give small quantities of mild stimulant.

164. **Starvation** may be relieved by at first giving very small quantities of mild food, at frequent intervals. A full meal should not be given for some time. Keep the body warm. Give water to drink freely.

165. **Sunstroke** is caused by excessive heat. If a person fall under such prostration, the skin will be "burning hot." Apply cold water at once, first to the head, then to the chest, and then to the extremities. Repeat the operation until consciousness is restored.

166. **If the clothing catches fire** wrap the body in a shawl, coat, blanket, or any such article, to extinguish the flames. If no wraps are near, roll on the ground or floor. Wet the clothing. Do not run in the open air.

167. **To escape from a burning house,** keep the doors and windows closed. If the smoke is great, remain near the floor. If you must pass through flame, wrap the body in a blanket. To protect the face and lungs, draw a wet woolen stocking over the head and face. Do not jump from the window. Tie the bed-clothing together at the corners, to make a long rope, fasten one end to the bed, and let yourself out and down from the window, by climbing along this rope.

168. **Choking** may usually be relieved by smart blows on the shoulders.

169. **In case of diarrhea,** go to bed, keep warm, and lie quietly on the back. Rest is better than medicine. Eat sparingly. Use no solid food.

170. **If bitten by a snake or mad dog,** wash the wound thoroughly, or suck it strongly. Rub it with caustic soda or carbolic acid, or burn it with an iron heated

"white hot." Whisky drank freely proves to be a useful remedy.

171. **Poisons.**—Many poisons so closely resemble articles in common use that all dangerous substances should be plainly marked, and all unknown substances should be destroyed. When healthy persons are taken ill, severely and suddenly, soon after swallowing some substance, it is probable that it is the effects of poison. In cases of poisoning, empty the stomach promptly. This may be done by drinking a cup or two of warm water, in which has been stirred a tablespoonful of ground mustard or common salt. The vomiting should be continued until the stomach is thoroughly emptied. Besides emptying the stomach, the effects of the poison may be counteracted by the action of some substance of a different nature. The following antidotes may be used:

The acids most likely to be used as poisons are *muriatic*, *nitric*, and *sulphuric*. These acids, if swallowed, destroy the mucous membrane of the stomach, and, in sufficient quantities, they will corrode the entire walls of the alimentary canal. The *antidotes* are the various alkalies, such as strong soap-suds, chalk, saleratus in water, and lime-water.

The alkalies most likely to be used as poisons are *ammonia*, and some forms of *potassa*. These substances burn the walls of the alimentary canal. The *antidotes* are the vegetable acids, given in dilute form, such as weak vinegar, or tartaric acid dissolved in water. Oils, such as castor oil, linseed oil, sweet oil, or cream, may be used to antidote the alkalies. Vomiting should be caused afterwards, to relieve the stomach of its contents.

Alcoholic liquors are poisonous, and, when they cause intoxication, the stomach should be emptied by vomiting, or by the use of a stomach-pump. Many compounds of copper are poisonous, and copper vessels should not be used, therefore, in cooking.

Common *arsenic*, in any of its forms, such as *white arsenic*, *Fowler's solution*, or *Paris green*, is a horrid poison. To relieve it, cause vomiting by the use of mustard or ipecac. The *antidote* is the hydrated peroxide of iron. Use lime-water if Fowler's solution has been taken.

Sugar of lead (acetate of lead) and *white lead* are poisons. Beside vomiting, use epsom salts as an antidote.

Any of the *mercurial preparations* are poisonous. Use white of eggs and milk as antidotes.

The most common narcotic poisons are *opium*, *aconite*, *belladonna*, *hemlock*, *digitalis*, *tobacco*, *nux vomica*, and *strichnine.* Empty the stomach by using mustard or alum. Give strong coffee. Keep the sufferer in motion as much as possible. With nux vomica and strichnia allay spasms by use of chloroform.

Suggestive Questions.

What is sickness? What does the sick person need? What are the objections to the use of a small, dark room for the sick? If a person is suffering severe pain, how may you relieve it? Why should broken bones be held in natural position while mending? How may you know that an artery is cut? Where must pressure be made to stop the bleeding of arteries? How may you stop the pain of a burn or scald? How is death caused in cases of drowning? What do you think is the condition of the lungs of the person who is drowned? How may breathing be restored? Why does foul air suffocate?

How would you restore one to life who is nearly frozen to death? Why will green leaves or a damp cloth worn in the hat aid in preventing sunstroke? How may you put out the fire, if your own clothing is burning? How may you escape from a burning house? How should you treat diarrhea? If you receive a poisonous bite, how would you treat the wound? What are the symptoms of poisoning? If persons have swallowed poison, what is the first thing to be done? In what ways may vomiting be caused? What common acids are poisons? What common alkalies will antidote these poi-

sons? If strong lye or other alkalies be swallowed, what common substances may be used to prevent their injurious effects? Why should all substances that are kept about the house be plainly marked? Why should we not use copper or leaden vessels for cooking purposes?

SUPPLEMENT.

ALCOHOL.

ITS EFFECTS ON BODY AND MIND.

172. **Alcohol.**—The fluid commonly known as alcohol is produced by the fermentation of sugar. Sugar is a vegetable product; so also is starch. Since starch can be converted into sugar (Note 2, Chap. VII.), these two substances may be viewed together as the usual sources from which alcohol is produced. The starch and sugar used for this purpose are derived from various fruits, grains, and tubers, such as the apple and grape, corn and rye, potato and beet. Vast quantities of these articles, so commonly used for food, are employed each year in the making of alcohol.

173. **Fermentation.**—The process by which alcohol is made from sugar is called fermentation. The sugar is decomposed, so that it ceases to be sugar, and becomes two other substances: (1) A volatile fluid, called alcohol; (2) a gaseous fluid, called carbonic acid. Sugar does not of itself readily decompose, but when certain substances are put with the sugar, it speedily undergoes change. The juice of apples is sweet when first made into cider. It is sweet because of the sugar in it. If the cider is kept at a summer temperature, it rapidly undergoes a change, by which bubbles of gas arise from it, and it loses its sweetness and acquires a very different taste and odor. The sugar in the cider

changes to carbonic acid, which forms the bubbles of gas, and to alcohol, which gives the new taste and odor.

If we take a few drops of ordinary molasses and mix with it some warm water and a few grains of common baker's yeast, the sugar of the molasses will turn to carbonic acid and alcohol.

If such grains as wheat, barley, and corn are kept moist and warm, they will begin to grow. If we chew these growing grains we shall find them to be sweet. Their starch has partly turned to sugar. If they were fermented while in this condition, their sugar would produce alcohol.

Almost all the alcohol that is produced by man is made in ways like these we have just described, only on a very large scale. It is in such ways that the alcoholic beverages, enumerated in Note 7, Chapter VI., are made.

174. **Distillation.**—Alcohol boils at a lower temperature than water does. By heating a mixture of water and alcohol until it is above the boiling point of alcohol, but below the boiling point of water, we may drive the alcohol off in the form of steam, and have the greater portion of the water left behind. If this steam is condensed in a cold vessel, we shall have all of the alcohol and some of the water. This process is called distillation. In this way distilled liquors are made from fermented liquors (Note 7, Chapter VI.).

175. **Properties and Uses.**—Alcohol resembles water in appearance. It is lighter than water. It has a mild odor and a pungent taste. It is very volatile, and burns readily. It will dissolve gums, oils, and resins; hence it is much used in making varnishes. Because of its power of dissolving gums and oils, it is used in extracting these substances from various leaves, barks, seeds, and roots, so that a large class of alcoholic tinctures are thus made.

The use of alcohol in the preparation of beverages is by far its greatest use. Almost all beverages that intoxicate owe that property to the alcohol they contain. Beer, wine,

and whisky owe their intoxicating effects to the alcohol they contain (Article 51, and Note 7, Chapter VI.).

176. Alcohol as Drink.—It has been stated in Article 50, how largely the body is composed of water, and how urgent is the demand for drink.

A proper drink is such as will supply the demand for water, without introducing any hurtful substances. The universal drink is ordinary water. This seems to be the natural drink. Water quenches thirst, and fills the different parts of the system with their needed quantity of liquids.

If substances that have a great attraction for water are taken into the body, they will draw the water from the various tissues. If the attraction is great enough, they will decompose the tissues. Substances that are called caustics destroy the flesh by their intense attraction for the water in the flesh. Common lye, lime, sulphuric acid, and carbolic acid destroy flesh in this way.

Substances having a milder attraction for water do not destroy the tissues, but draw the free water from them. This causes the tissues to shrink, to harden, and to stiffen. Substances of this kind, whether taken as drink or food, produce thirst. Common salt and alcohol act in this manner.

If the strongest form of alcohol is taken into the mouth or stomach, it will blister the mucous membrane, and decompose the structure of the parts, so great is its affinity for the water they contain. If dilute alcohol be introduced, the same kind of action occurs in less degree of violence. Thirst is always produced by the drinking of any kind of alcohol. A natural drink always slakes thirst. The large amount of water in some drinks, with the small portion of alcohol they contain, enables them to allay thirst; such is the action of beer. It is the water, however, and not the alcohol, that gratifies the thirst. The water of the beer would quench the thirst more readily if the alcohol were

not present. Examinations prove that the tissues of those who are addicted to the use of alcoholic beverages are hardened by the loss of their water. This is especially true of the nervous tissue of those who die from the evil effects of alcohol.

It is the purpose of the circulatory fluids to aid in digesting the food and to hold the food particles in solution. Alcohol, if used in other than extremely small quantities, tends to hinder the digestion of food, and to make the albuminoids less easily dissolved. By the action of the alcohol on the nerves and muscles of the stomach, the operations of the stomach are less vigorous. Alcohol seems to act as the reverse of a proper article of drink. It is a mistake to think that alcohol is a true beverage.[1]

177. **Alcohol as Food.**—Food gratifies hunger, and maintains the strength, warmth, and vigor of the body. If alcohol is taken into the alimentary canal, it passes directly into the blood, and is distributed throughout the body. It goes into the blood as alcohol. It is distributed as alcohol. It is finally cast out of the body as alcohol. It undergoes little or no change in the body. It does not appease hunger. It does not supply any lasting strength to the tissues. Food and alcohol are directly opposite in their action. It is a mistake to suppose that alcohol is a food.[1]

178. **Alcohol as a Heat-producer.**—The body must be kept warm. This is done by the union of the oxygen we breathe with certain substances in the blood. This kind of burning produces carbonic acid. If there is much heat produced, there is much carbonic acid formed. All heat-producing articles of food incline to increase the warmth of the body. If the oxygen were to act on the alcohol as it does on other substances in the blood, much warmth would thereby result, and much carbonic acid would be formed. The facts are, however, that, since alcohol undergoes little or no change in its passage through the circula-

tion and the tissues, the quantity of carbonic acid exhaled from the lungs of a man under the influence of alcohol is much less than the amount from the same lungs when the man has no alcohol in his system. The temperature of the body is lowered, rather than raised, by the action of alcohol.[2]

Dr. W. B. Carpenter says: "For a few minutes after alcohol is administered, to the amount of a gill of wine or brandy, the temperature rises slightly, after which it falls several degrees below the standard of health, and remains so for hours."

Heat-producing foods increase the strength and vitality, and enable us to withstand great cold.

Dr. Austin Flint says: "It is not proved that alcohol enables men to endure a very low temperature for a great length of time. This end can be accomplished only by an increased quantity of food."

If alcohol tends to lower the temperature of the body, and to make men less able to withstand exposure to low temperature, it must be a mistake to regard alcohol as a heat-producer.

179. **The Effects of Alcohol on the Blood.**—Alcohol holds to the blood, because the blood is so largely composed of water. The alcohol causes the corpuscles to shrink and to become wrinkled and ragged. By this action, the corpuscles can not perform their purposes so well. They can not so well carry oxygen to the tissues, nor bear away the carbonic acid from the system.

The fibrine of the blood is injuriously affected by alcohol. The blood of persons who are addicted to the use of alcoholic liquors does not coagulate naturally.

The habitual presence of alcohol in the blood injures the blood itself, and also causes the great organs of circulation to become diseased. The heart and liver especially become weakened and diseased.

Because of the injurious effects of alcohol on the blood and organs of circulation, persons who use it freely as a beverage are likely to become diseased. They suffer because the impurities of the body are not removed promptly, and because digestion and circulation are not performed naturally. Such persons are less able to withstand hardship, and are more likely to take diseases in case of epidemics.

180. Effects of Alcohol on the Nerves.—The nerves lead from the brain to all parts of the body. It is through the nerves that we move the muscles, and by them that we feel. Whatever affects the nerves affects our power to move and to feel. The brain appears to be the instrument most closely connected with the mind. Whatever affects the nervous system affects the mind. Motion, feeling, and mental action are all dependent on the nervous system.

Alcohol has very decided effects upon the nerves and brain.[3] When alcohol comes in contact with nerves, it causes them to contract and to become more hard. The nerves and brain of persons who die from the effects of alcohol are noticeably hardened. By this change in the nerves, they become partially paralyzed, and unfit for their purposes as feelers and movers. If we hold alcohol in the mouth for a short time, we can not taste so acutely afterwards, because the nerves of taste are somewhat deadened by the alcohol. If we hold alcohol in the mouth about a tooth, the tooth may be extracted with but little pain, because the nerves are blunted in feeling. If from some cause there is pain in the stomach, by swallowing alcohol the pain ceases. The "pain is cured" because the nerves become less sensitive, so that we do not feel the pain. Persons who are under the influence of alcohol are quite insensible to blows, bruises, and burns, because their nerves are partially paralyzed. As alcohol lessens the power to feel, so does it weaken the power to move. A person under its influence

can not control his motions so well, and he is not so strong as when free from its influence.

181. **Stimulants.**—When alcohol is taken into the system its first effects are to arouse and alarm the system. For a brief season, the person feels stronger, the heart beats more rapidly, and the skin is flushed. The mind of the person is also brightened and cheered. This is called stimulation. Such effects are only temporary. Similar effects are produced by many other substances. Almost all poisons are stimulants.

182. **Narcotics** are substances that tend to cause paralysis of the nerves. They tend to produce depression, stupor, and death. Almost all narcotics produce stimulation at first. This is followed by depression.

183. **Alcohol as a Stimulant.**—There is little doubt that alcohol, when taken into the system, does for a brief time give tone and vigor. It acts as a stimulant. The person feels stronger, both in muscle and mind. Its use as a stimulant is wholly needless with persons in good health. With persons who are invalids, the propriety of its use is questionable, because of the reaction that must follow stimulation, and the inflammation to the nerves and blood-vessels that must ensue. Surely no one but a skillful and conscientious physician is competent to administer it in any case. The action of alcohol is deceptive. "Whosoever is deceived thereby is not wise."

184. **Alcohol as a Narcotic.**—The use of alcohol in large quantities, or in small quantities that are often repeated, invariably causes narcotic depression. It tends to produce mental and physical stupor, low temperature, and death. The use of alcohol, in which the narcotic effects are in the least degree noticeable, is, without question, evil. There is no difference of opinion among physiologists on this point.

185. **Stages of the Action of Alcohol.**—As before stated, the *first* effect of alcohol is to produce stimulation.

This effect is temporary. The *second* stage of action is depression. In this stage, there is chilliness and fall of temperature, and loss of mental and muscular control. With strong persons, this stage may not be very noticeable; with weak persons, it is often decided and alarming. The *third* degree of alcoholic action, which is caused by a greater quantity of alcohol, is intoxication. In this stage, the organs become filled with blood, and the nervous system becomes greatly deranged; the mind loses its power to control the body; the breathing is slower; the heart beats less rapidly; and the temperature becomes lower. The *fourth* stage is that of unconsciousness. The individual loses all mental control. He can not see, hear, or feel. He lies helpless. The action of the heart is irregular and weak. His breathing is slow and clogged. The person borders upon death from the narcotic effects of alcohol.

186. **The Mind and the Nervous System.**—The mind and the nervous system are very closely connected. In general, it is true that mental action is most clear and forcible only when the nervous system is most healthy and vigorous. If the nervous system is diseased or inflamed, the powers to understand and to control are weakened and unreliable.

187. **Effects of Alcohol on the Mind.**—The stimulating effects of alcohol upon the nervous system usually cause the individual to feel bright and jovial. He fancies himself strong and agreeable. With some persons, however, the effects are to render them extremely silly. Others grow stupid. Still others become furious. The narcotic effects of alcohol cause decided mental depression and loss of control.

188. **Alcohol Affects the Whole Mind.**—Whatever may be the relation of the nervous system and the mind, the effects of alcohol on the former cause the latter to be changed in all of its faculties. The effects of its action are

seen in: (1) A confused and faulty perception of feeling—the person can not think rightly; (2) the memory becomes less clear; (3) the imagination runs wild; (4) the finer sensibilities are blunted; (5) there is less power of self-control.

Under the influence of alcohol, the whole nature may be changed. The kind and gentle sometimes become cruel and destructive; the refined and delicate grow coarse and vulgar.

The effects of alcohol on the mind, as briefly stated above, are caused by its paralyzing and inflaming action upon the brain and other parts of the nervous system.

189. **The Will Especially Affected.**—The most decided and alarming effects of alcohol on body and mind is its tendency to weaken the will, and to fix upon the system a powerful appetite for alcohol.

Because alcohol weakens the understanding and blunts the feelings, the person under its influence loses that keen sense of right and duty that is so necessary in the action of the will. At the same time, it is true that the nervous system inclines to adapt itself to the kind of treatment we give it. If we take alcohol, or any other narcotic, frequently and regularly, the system soon becomes so accustomed to the effects of the narcotic that it will demand the substance at our hands by an appetite that is very difficult to control. Both the mind and body are disposed to form habits. As we have done once under certain circumstances, we are disposed to do again under the same conditions. The oftener we act in a certain way, the more powerful becomes the habit to continue such action. The use of alcohol grows in this way to be a powerful habit, which often overcomes the strongest wills and most determined resolutions. The growth of this habit is rapid. The appetite thus formed is called the narcotic appetite. The same appetite is readily formed for tobacco, opium, chloral, or any other narcotic.

190. The System Demands Increased Quantities of Alcohol.—Not only does the system acquire an appetite for alcohol if we begin the use of it, but usually it demands more and more in point of quantity. At first, a small quantity will produce a certain effect. As the system becomes accustomed to the action of the alcohol, it requires a greater quantity to produce the desired effect. Later in the use of the substance, as the system grows less sensitive, it requires still greater quantities. It is usually true that persons who become accustomed to the use of alcohol increase steadily in their habit; they drink more often, and they drink greater quantities.

191. The Evil Consequences May Be Transmitted.—It is true of all living things, that the off-spring is like its parents. Just as every living thing originates from some parent body, it is equally true that the conditions of the parent affect the constitution of the off-spring. Children inherit from their parents both physical and mental features. It is equally true, that children born of parents who are profoundly diseased, inherit deep-seated tendencies to similar diseases. So, too, children whose parents are addicted to the use of alcohol, or other narcotics, suffer from the effects of such diseased conditions in their parents. Children whose parents are lovers of narcotics, are likely to inherit similar passion. Such children show these appetites more often than do the children from parents who are not given to the use of narcotics. Such children are liable to inherit nervous disease and weakness.

192. Objections to the Moderate Use of Alcohol.—Very many persons use alcoholic drinks in what is termed "the moderate use" of alcohol. They use alcohol in such moderate quantities as not to cause intoxication. These persons drink moderately of wine and beer. They drink these substances on account of the alcohol contained in them. If these persons have used alcoholic beverages until

they have formed an appetite for such drinks, the alcohol they take satisfies their craving, and, for this reason, they think it to be a very good thing. It is this tendency to form a narcotic appetite, that is one of the chief objections to the "moderate use" of alcohol.

Alcohol is universally classed as a poison. Its moderate use must be objectionable, for the same reason that we would object to the moderate use of arsenic, strichnine, or other poisons.[3]

The moderate use of alcohol tends to produce diseased conditions of the organs of circulation; and, by inflaming the nervous system, it tends to weaken both body and mind. The example is evil.

193. **A Cause of Insanity.**—Insanity is one of the most deplorable of human afflictions. It is now generally believed by physiologists that insanity is, in all cases, due to diseased conditions of the nervous system. Because alcohol acts in all cases as a brain poison, its use tends to cause conditions favorable to insanity.[4]

Intoxication itself is temporary insanity. It is not surprising that frequently repeated intoxication tends to produce confirmed mania.

Statistics derived from various asylums, both in England and the United States, show that the use of alcohol is one among the great causes of insanity.

A committee in England extended their observations through sixteen years, and reached the conclusion that as many as sixty out of every hundred cases of insanity in that country, during the time of their investigation, were caused by the intemperate use of alcohol. Doubtless one half the cases of insanity in the United States are due directly or indirectly to the immoderate use of alcohol and other narcotics.

194. **The Use of Alcohol Prepares for Crime.**—The fact that a person who is under the influence of alcohol loses

the clearness of his understanding, so that he no longer appreciates the rightness or wrongness of his actions, and does not see the consequences of his deeds, prepares him to do evil.

Added to his lack of judgment, the intoxicated person seems indifferent to all appeals from others who would guide him.

Beside the tendency of alcoholic drinks to cloud the mind, they inflame the passions most powerfully. For this reason, they put the individual in the very condition to commit desperate acts. Frequently, those who are kind when sober, are dangerous and vicious when under the influence of alcohol.

The law holds the criminal responsible for his acts, although they are committed while intoxicated. Otherwise, all crime might prepare for its deeds, and defend itself by intoxication.

Criminal judges agree in the opinion that a very large proportion of all the criminals that come before them for trial owe their crimes to the influence of alcoholic drinks. Police reports show that by far the greater number of arrests are for intoxication.

195. Conclusions Concerning Alcohol.—As shown by the foregoing, nothing beneficial comes from the use of alcohol as a beverage. Its influence is evil. It tends to produce thirst. It disturbs the natural operations of digestion. It injures the blood. It lowers the temperature. It inflames the nervous system. It produces conditions that result in disease. It is a cause of insanity. It prepares its victims to commit crime. It visits its evil consequences from parents upon their children. It endangers the morals, the honor, and the happiness of its victims. It is not designed for food or drink. Its use, even as a medicine, should be confined strictly to the direction of a skillful physician.

Notes.

1. Dr. Wm. B. Carpenter, formerly Examiner in Physiology and Comparative Anatomy in the University of London, says: "The use of alcohol in combination with water and with organic and saline compounds, in the various forms of fermented liquors, deserves particular notice, on account of the numerous fallacies which are in vogue respecting it. In the *first* place, it may be safely affirmed that alcohol can not answer any one of those important purposes for which the use of water is required in the system; and that, on the other hand, it tends to antagonize many of those purposes. * * * * *Secondly*, the taking of alcoholic liquors into the stomach can not supply any thing which is essential to the nutrition of the system; since we find, not only individuals, but whole nations, maintaining the highest vigor and activity, both of body and of mind, without ever employing them as an article of diet. *Thirdly*, there is no reason to believe that alcohol, in any of its forms, can aid directly in the nutrition of the tissues, for it may be certainly affirmed that it is incapable of transformation into albuminous compounds; and there is no sufficient evidence that even fatty matter can be generated in the body at its expense. It is quite true that some persons who consume large quantities of fermented liquors become very fat; but the material for this fat is probably derived in part from the waste matter of the tissues. * * * *Fourthly*, the alimentary value of alcohol consists merely in its power of contributing to the production of heat; but, for this purpose, it would be pronounced, on chemical grounds, to be inferior to fat; and the results of the experience of Arctic voyagers and travelers is most decided in regard to the comparative low value of alcohol as a heat-producing material. *Fifthly*, the operation of alcohol upon the living body is essentially that of a stimulant; * * * being followed by a corresponding depression of power, in proportion as the previous excitement has been greater. Nothing, therefore, is, in the end, gained by its use. Its use is only justifiable where some temporary emergencies can only be met by a temporary increase of power, even at the expense of an increased amount of subsequent depression; or where it affords aid in the introduction of aliment into the system, which nothing else can so well supply. These exceptional cases, however, will be less numerous, in proportion as due attention is paid to those other means of promoting health, which are more in accordance with nature."

2. Dr. Hayes, the Arctic Explorer, says: "While fresh animal food, especially fat, is absolutely essential to the inhabitants and travelers in Arctic countries, alcohol is not only completely useless, but positively injurious. I have known the most unpleasant consequences to result from the injudicious use of whisky for the purpose of temporary stimulation, and have also known strong, able-bodied men to become utterly incapable of resisting cold in consequence of the long-continued use of alcoholics."

Dr. Frank H. Hamilton, in writing concerning an experiment, in the army of the Potomac, of giving to each soldier one gill of whisky per day, because of the great hardship and exposure to which the army was at one time exposed, says: "It is earnestly desired that no such experiment will ever be repeated in the armies of the United States. In our own mind, the conviction is established, by the experience and observation of a life, that the regular routine employment of alcoholic stimulants by man in health is never, under any circumstances, useful. We make no exceptions in favor of cold or heat or rain."

3. Dr. Wm. Jay Youmans says: "It is to the nervous system, and especially to its great center, the brain, that alcohol is first attracted after it has entered the circulation. It is to all intents and purposes a cerebral poison."

Dr. Muzzey, of Ohio, says: "That alcohol is a poison to our organization, is evident from observation. * * * * What is a poison? It is any substance, in whatever form it may be, which, when applied to a living surface, disconcerts life's healthy movement. * * * * Such a poison is alcohol; such, in all its forms, mix it as you may. It is never digested and converted into nourishment."

Dr. James Edmunds, of England, says: "We have a great horror of arsenic and fifty other poisons; while the fact is, that all these things are a mere bagatelle in relation to the most direct, absolute, immediate, and certain poisonings which are caused by alcohol."

4. Dr. Yellowlees, Medical Superintendent of the Glamorgan County Asylum, England, says: "With the single exception of hereditary predisposition, intemperance is, by far, the most fruitful of all the causes of brain disease, and even hereditary predisposition is often but another name for parental intemperance. * * * * It is surely within the truth to say that half the existing cases of insanity are due directly or indirectly to this social curse. * * * No vice is more hereditary than intemperance."

Suggestive Questions.

From what materials is alcohol made? What is fermentation? What two substances are produced by fermentation? What is cider? What change occurs in sweet cider if it is kept warm, and open to the air? What is distillation? What are the properties of alcohol? What are its uses? What is the chief use of alcohol? What gives the intoxicating property to wine, beer, and whisky? How does alcohol differ from a natural drink? Why does strong alcohol blister the mucous membrane? Does alcohol aid or hinder digestion? How does alcohol differ from food? Does alcohol cause the temperature of the body to rise or to fall? Does alcohol enable men to stand great exposure? Does alcohol give great strength? How does alcohol affect the blood? What is true of the healthfulness of those who use alcoholic beverages? What organs are specially liable to disease by the use of alcohol? Who are most likely to suffer from disease in epidemics? What are the effects of alcohol on the nerves? How does alcohol allay pain? Does it make the person who drinks it strong or weak? What are stimulants? What are narcotics? Is alcohol needed by the healthy person? How is the action of alcohol deceptive?

How does alcohol affect the mind? What faculty of the mind does alcohol specially affect? What is the narcotic appetite? What substances will produce narcotic appetite? Why do persons who use alcohol usually increase the quantity? What dangers of transmission attend the use of alcohol? What are the objections to the moderate use of alcohol? Why does alcohol tend to cause insanity? How does alcohol prepare persons to commit crime? What is the opinion of criminal judges concerning the effects of alcohol? What are the general conclusions concerning alcohol?

GLOSSARY.

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Ab-dō′men (L. *abdere*, to conceal). The cavity containing the stomach, intestines, liver, etc.

Ad′i-pōse. Fatty.

Al-bū′men (L. *albus*, white). An animal substance, much like the white of egg.

Al-i-mĕnt′a-ry (L.). Pertaining to food.

A-năt′o-my (G. *ana*, through; *tome*, a cutting). A description of the structure of any living thing.

A-ôr′ta (G. to hold air). The great artery that conducts the blood from the left ventricle of the heart.

A′que-oŭs (L.), like water.

Ar′ter-y (G. to hold air). The tubes that conduct the blood from the heart.

Au′di-to-ry (L. *audio*, to hear). Pertaining to the special sense, hearing.

Au′ri-cle (L. *auris*, ear). The upper cavities of the heart, having the shape of ears.

Bī′çeps (L. *bis*, twice; *caput*, head). Having two heads.

Bī-cŭs′pid (L. *bis*, twice; *cuspis*, point). Having two points.

Brŏn′chi-al (G. *bronkos*, windpipe). Pertaining to the branches of the trachea for the passage of the air in the lungs.

Brŏn-chī′tis (G. *bronkos*, and *itis*, inflammation). Inflammation of the bronchial tubes.

Bŭc-çi-nā′tor (L. *buccinum*, a trumpet). The muscles of the cheek used in blowing a trumpet.

Caf-fē′ĭne. (F.) The active principle of coffee.

Cal-cā′re-ous (L. *calx*, lime). Having the nature of lime.

Căp′il-la-ry (L. *capillus*, a hair). Resembling a hair or other minute tube.

Căp′sūle (L. *capsula*, a small chest). A membraneous sac, or small bag enclosing a part.

Cär′di-ac (G. *cardia*, the heart). Pertaining to the heart.

Cär′pus (G.). The wrist.

Cär′ti-lage (L. *cartilago*). An elastic material, of a solid but flexible nature.

Cā′se-ĭne (L. *caseus*, cheese). The curd of milk.

Cĕll. A tiny sack-like body, containing the growing matter of the body.

Cĕr-e-bĕl′lum (L.). The little brain.

Cĕr′e-bro-spī′nal. Pertaining to the brain and spinal cord.

Cĕr′e-brŭm (L.). The large portion of the brain filling the front and upper portions of the cranium.

Chō′roid (G. *chorion*, a cover). The middle cover of the ball of the eye.

Chȳle (G. *chulos*, juice). The milk-like juice derived from the digestion of the food in the intestines.

Cĭl′i-a (L. *cilia*, eye-lashes). Minute, hair-like cells that line the inner air passages and other parts.

Clăv′i-cle (L. *clavis*, a key). The collar bone.

Co-ăg-ū-lā′tion (L.) The act of turning from a fluid to a clotty or curdy mass.

Cō-a-lĕsçe′. To unite.

Cŏc′çyx (G.). A mass of small bones appended to the lower portion of the sacrum.

Cŏch′le-a (L. *cochlea*, a screw). A portion of the inner ear having the shape of a snail-shell.

Cŏn′cha (G. *konche*, a shell). The outer portion of the external ear.

Cŏn-jŭnc′ti-va (L. *con*, and *jungo*, to join together). The thin membrane which lines the eye-lids and covers the front portion of the eye-ball.

Con-strĭct′or. That which draws together.

Cŏn-vo-lū′tion (L. *con*, and *volvere*, to roll). The act of folding or rolling together.

Côr′ne-a (L. *cornu*, a horn). The horn-like membrane forming the outer wall of the front portion of the eye-ball.

Côr′po-ră (L. *corpus*, a body). A name applied to various bodies found in the brain and in other parts of the body.

Côr′pus-çles (L. diminutive of corpus). Tiny bodies that float in the plasma of the blood.

Cŏr′ru-gā-tor (F.). A muscle that wrinkles the brow.

Crȳs′tal-līne (L. *crystallum*, a crystal). Resembling crystal.

Cŭs′pid (L. *cuspis*, a point). Having one point.

Cū′ti-cle (L. diminutive of *cutis*). The outer layer of the skin.

Cū′tis (L. *cutis*, skin). The inner layer of the skin, or true skin.

Dĕl′toid (G. *Delta*, the letter △). Having the shape of the Greek letter Delta.

Dĕn′tīne (L. *dens*, tooth). The substance that forms the body of the teeth.

Dī′a-phrăgm (G. *diaphragma*, a partition). The partition that separates the chest and abdomen.

Dī-ar-rhē′a (G. *diarrhea*, to flow through). An unnatural frequency of evacuation of the intestines.

Dī-găs′tri-cus (G.). Having two swells.

Dī-gĕs′tion (L. *digestio*, to separate). The act of separating the nutrient portions from the food taken into the alimentary canal.

Dū-o-dē′num (L. *duodeni*, twelve). The first twelve finger-breadths in length of the small intestines.

Dys-pĕp′si-a (G. *dus*, bad; *pepto*, to digest). That condition of the digestive organs in which they fail to perform digestion readily.

E-mŭl′si-fy (L. *emul′geo*, to milk). To turn into the form of milk.

En-ăm′el (F. *email*). The flinty substance that covers the crown of the teeth.

En-dos-mō′sis (G. *endon*, within; *osmos*, to push). The passage of fluids through membranes toward the inner part of the vessel.

En-tĕr′ic. Pertaining to the intestines.

Ep-i-glŏt′tis (G. *epi*, upon; *glottis*, the entrance to the larynx). The lid-like cover that fits over the larnyx at time of swallowing.

E-sŏph′a-gŭs (G.). The tube that conducts the food to the stomach.

Eth′moid (G. *ethmos*, a sieve). A bone at the base of the skull pierced by many holes.

Ū-stā′chi-an Tube. The passage connecting the middle portion of the ear with the air passages of the throat.

Ex-crē′tion (L. *excerno*, to separate). The process of separating and casting out waste matter.

Fē′mur (L.). The thigh-bone.

Fī′ber (L. *fibra*). A tiny filament or thread which enters into the structure of any tissue.

Fī′brīne (L. *fibra*). A substance contained in the blood, which coagulates into a fibrous mass.

Fĭb′ū-la (L. a clasp). The outer bone of the leg.

Flĕx′ion (L. *flectio*, to turn). The act of bending.

Flĕx′or. A muscle that bends a joint.

Frŏnt′al. Pertaining to the fore-part.

Fŭnc′tion (L. *fungor*, to perform). The service performed by any organ.

Găn′gli-on (G. a knot). An englargement in the course of a nerve, or mass of gray nervous matter.

Găs-trŏc-nē′mi-ŭs (G. *gaster*, the stomach; *kneme*, leg). The name of the large muscles of the leg.

Germ. A separate portion of organic matter possessing the properties of growth.

Glănd. An organ designed to separate certain fluids from the blood.

Glū′tæ-ŭs (G.). The name of the muscles of the hip.

Hĕm′or-rhage (G. *haima*, blood; *regnuo*, to burst). Bleeding.

He-păt′ic. Pertaining to the liver.

Hū′me-rŭs (L.). The bone of the arm.

Hū′mor (L. liquid). The humors are the liquid contents of the eye-ball.

Hȳ′gi-ēne (G. *huygieia*, health). The science of health.

Hȳ′oid. Having the shape of the letter V. The bone at the base of the tongue is called the hyoid bone for this reason.

I-lĭ′a-cus (L.). Pertaining to the groin.

In-cī′sor (L. *incido*, to cut). A term applied to the front teeth.

In-nŏm-i-nā´ta (L. *in*, not; *nomen*, name). Parts having no proper name.

In-ter-cŏs´tal (L. *inter*, between; *costa*, rib). Between the ribs.

In-tĕs´tĭnes (L. *intus*, within). The canal leading from the stomach.

I´ris (L. the rain-bow). The colored membrane surrounding the pupil of the eye.

Lăch´ry-mal (L. *lachryma*, a tear). Pertaining to the tears.

Lăc´te-al (L. *lac*, milk). A tube conveying the chyle from the intestines to the veins.

Lăr´ynx (G. *larunx*). The cartilaginous box containing the vocal cords.

Lā-tĭs´si-mŭs (L.). Broadest.

Le-vā´tor (L. *levo*, to raise). Applied to muscles that raise parts.

Lĭg´a-ments (L. *ligo*, to bind). The fibrous membranes that bind the joints together.

Lŭm´bar (L. *lumbus*, loin). Pertaining to the loin.

Lym-phăt´ic (L. *lympha*, water). Applied to the parts that convey the lymph or watery part of the blood.

Mā´lar (L. the cheek). The cheek-bone.

Măs´se-ter (G.). The name applied to the muscles that move the muscles in chewing.

Măs´toid (F.). Resembling a breast.

Max-ĭl´la (L.). The jaw-bone.

Me-dŭl´la (L.). Marrow.

Me-dŭl´la Ob-lon-gä´ta. The marrow of the spinal column continued into the skull to join with the brain.

Mĕm´brāne. A thin network of fibers forming a cover or body.

Mĕs´en-tĕr-y (G. *mesos*, middle; *enteron*, intestines). The membrane by which the intestines are held to the spinal column.

Mĕt-a-căr´pals (G. *meta*, beyond; *karpos*, wrist). The body of the hand.

Mĕt-a-tăr´sus (G. *meta*, beyond; *tarsos*, a broad flat surface). The body of the foot.

Mī´tral (L. *mitra*, a mitre). Applied to the valves in the left side of the heart.

Mō′lar (L. *mola*, a mill). The teeth used in grinding the food.

Mō′tor (L. *motum*, to move). Causing motion.

Nar-cŏt′ic (G. to benumb). Allaying pain, benumbing feeling, producing sleep.

Nā′sal (L. *nasus*, the nose). Pertaining to the nose.

Oc′çi-pŭt (L. *ob*, and; *caput*, the head). The back part of the head.

Ol-făc′to-ry (L. *oleo*, to smell; and *facio*, to make). Pertaining to smelling.

O′pi-ŭm. Dried juice of the poppy. A narcotic.

Op′tic (G. *opto*, to see). Pertaining to seeing.

Or-bĭc′ū-lar (L. *orbis*, an orb). Circular.

Or′gan. A portion of any living thing designed to perform some particular work in the life of the body.

Or′gan-ĭsm. A living thing.

Os-mō′sis (G. *osmos*, to push). The passage of fluids through membranes.

Os′se-oŭs (L. *os*, bone). Bony.

Os′si-cle (L. diminutive of *os*, bone). A tiny bone.

Păl′ate (L.). The roof of the mouth.

Păl′pe-bral (L.). Pertaining to the eye-brow.

Păn′cre-as (G. *pan*, all; *kreas*, flesh). A digestive organ adjacent to the stomach.

Pa-pĭl′la (L.). A minute prominence designed for the termination of a nerve.

Pa-răl′y-sĭs. Loss of nervous function, whether of intellect, feeling, or motion.

Pa-ri′e-tal (L. *paries*, a wall). Pertaining to the walls of a cavity.

Pa-tĕl′la (L. diminutive of *patina*, a pan). The small bone fitting into the knee in front.

Pec-tŏr-ā′lis (L.). Pertaining to the chest.

Pĕl′vis (L.). The basin of bones upon which the trunk is supported.

Pĕp′sin (G. *pepto*, to digest). The element of the gastric juice which ferments the contents of the stomach.

Pĕr-i-căr′di-ŭm (G. *peri*, around; *kardia*, heart). The sack that encloses the heart.

Pĕr-i-ŏs′te-ŭm (G. *peri*, around; *os*, bone). The membrane that covers the bones.

Pĕr-o-nē′ŭs. The muscle near the small bone of the leg.

Pē′troŭs (L. *petra*, rock). Rock-like.

Phā′lanx (G. *phalanx*, an army). Any bone of the fingers or thumbs.

Phăr′ynx (G.). The upper portion of the esophagus.

Phȳs-i-ŏl′o-gy (G. *phusis*, nature; *logos*, discourse). The science of the use of organs.

Pĭg′ment (L.). Coloring matter.

Plăs′ma (G. formed). The blood, exclusive of the corpuscles.

Pleū′ra (G.). A thin membrane, lining the chest and covering the lungs.

Pleū′ri-sy. Inflammation of the the pleura.

Pneū-mō′ni-a (G. *pneumon*, the lungs). Inflammation of the air cells of the lungs.

Pōrt′al (L. *porta*, a gate). Pertaining to the entrance.

Prŏç′ess-es. Prominences upon the bones; also, a procedure.

Pro-nā′tor (L. *pronus*, face downward). Applied to muscles that turn the hand with the palm downward.

Prō′to-plăsm (G. *protos*, first; *plasma*, formed). The growing part of organisms.

Psō′as (G.). A muscle of the loin.

Ptȳ′a-līne (G. *ptualon*, saliva). The peculiar element of the saliva.

Pŭl′mo-na-ry (L. *pulmo*, the lungs). Pertaining to the lungs.

Pū′pil (L.). The central opening in the iris.

Pȳ-lō′rus (G. *puloros*, a gate-keeper). The opening from the stomach into the intestines.

Pȳr′i-fôrm. Having the shape of a pyramid.

Rā′di-ŭs (L. a ray). The revolving bone of the fore-arm.

Rĕc′tŭs (L.). Straight, erect.

Rē′-flex (L. *re*, back; *flectere*, to turn). Being turned back.

Rē′nal. Pertaining to the kidneys.

Rĕt′i-na (L. *rete*, a net). The inner coat of the back portion of the eye.

Sā′crum (L. sacred). The bone forming the back portion of the pelvis.

Sa-lī′va (L.). The fluid secreted into the mouth for moistening the food.

Sar-tō′ri-ŭs (L. *sartor*, a tailor). A muscle of the thigh.

Scăp′ū-la (L.). The shoulder-blade.

Scle-rŏt′ic (G. *skleros*, hard). The outer coat of the eye.

Scrŏf′ū-la. Disease of the lymphatic organs.

Se-bā′ceoŭs (L. *sebum*, tallow). Pertaining to fat.

Se-crēte′. To produce from the blood a substance different from the blood itself.

Sĕm-ĭ-lū′nar (L. *semi*, half; *luna*, moon). The name applied to valves having the shape of a half-moon.

Sĕn′so-ry. Pertaining to feeling.

Ser-rā′tus (L. *serra*, a saw). Notched.

Sē′rum (L.). The watery part of the blood.

Sphē′noid (G. *sphen*, a wedge). A name applied to a bone at the base of the skull.

Spīne. A thorn. The back-bone.

Stā′pēs (L. a stirrup). One of the ossicles of the ear.

Ster-no-măs′toid. Pertaining to the sternum and the mastoid process.

Ster′num. The breast-bone.

Stĭm′ū-lŭs. That which excites.

Sŭb-lĭn′gual (L. *sub*, under; *lingua*, tongue). Under the tongue.

Sŭb-măx′il-la-ry (L. *sub*, under; *maxilla*, jaw-bone). Under the jaw-bone.

Su-per-cĭl′i-i (L. *super*, above; *cilium*, eye-lid). A muscle that moves the eye-lid.

Sū-pi-nā′tor. A name applied to a muscle that turns the hand with palm upwards.

Sūt′ūre (L. *suo*, to sew. The ragged union of the bones of the skull.

Syn-ō′vi-a (G. *sun*, with; *oon*, egg-like). The fluid secreted in the joints.

Tăc′tīle. Pertaining to touch.

Tăr′sal (L.). The back portion of the foot.

Tĕm′po-ral. Pertaining to the temples.

Tĕn′don (G. *teino*, to stretch). The fibrous ends of the muscles that join the muscles to the bones.

Tēr′ēs (L.). Round.

Thăl′a-mŭs. A rounded surface in the brain.

Thē′ĭne. The active principle of tea.

Thō′rax (G.). The cavity of the chest.

Tĭb′i-a (L. a flute). The shin-bone.

Tĭs′sue. An organization of cells.

Tŏn′sils. Two glandular bodies in the throat.

Trā′che-a (G. *trachus*, rough). The wind-pipe.

Trī′cĕps (L. *tres*, three; *caput*, head). Muscles having three heads.

Trī-cŭs′pid (L. *tres*, three; *cuspis*, point). Having three points.

Tȳm′pa-nŭm (L.). The middle ear.

Tȳ′phoid (G.). Like typhus. Applied to low fevers affecting the intestines.

Ul′na (L. *ulna*, the elbow). The larger bone of the fore-arm.

Văs′tŭs (L.). Great.

Vĕn′tri-cle (L. diminutive of *venter*). A small cavity.

Ver′te-bra (L. *vertere*, to turn). A joint or segment of the spinal column.

Vĭl′lī (L.). Minute fibers.

Vĭs′çe-ra (L.). The contents of the great cavities of the body.

Vĭt′re-oŭs (L. *vitrum*, glass). Like glass.

Vŏl′un-ta-ry. Controlled by the will.

Vō′mer (L. a plowshare). The bone that forms the partition of the nose.

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